AMBIENT AIR QUALITY IN WINDSOR 1972 to 1977

Ontario
Ministry of the Environment

AMBIENT AIR QUALITY
IN
WINDSOR
1972 TO 1977

Technical Support Section
Southwestern Region
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SUMMARY

Ambient air quality in Windsor has demonstrated a marked improvement since 1972 with respect to both sulphur dioxide and particulates. The improvement in the control of sulphur dioxide emissions in Wayne County, Michigan and the shut-down of Ontario Hydro's J. C. Keith Power Generating Station contributed to the essential achievement of acceptable sulphur dioxide levels during 1977.

Although the improvement in levels of particulates has been appreciable since 1972, air quality in relation to dustfall and suspended particulates remains unsatisfactory. Also, the trend of decreasing levels of suspended particulates was most evident from 1972 through 1974. Since 1974, the levels have remained relatively uniform. West Windsor, which is influenced by particulate emissions from a heavily industrialized area of Wayne County, and a localized area of east Windsor near the Casting Plant of Ford Motor Company of Canada, Limited have the highest levels of dustfall and suspended particulates.

The improvement in levels of sulphur dioxide and particulates is reflected in the improvement in the Air Pollution Index since 1972. In 1977 there was only one period of eight hours when the Air Pollution Index marginally exceeded the Advisory Level of 32.

Data for carbon monoxide and nitrogen dioxide meet the respective criteria for desirable ambient air quality. There are no criteria for total hydrocarbons but there is no descernible trend towards increasing levels and values are similar to those determined in other communities.

The criterion for desirable ambient air quality with respect to ozone has been exceeded each year since monitoring commenced in 1974. Ozone is considered a broadly recognized problem as elevated levels of ozone have been reported for most of the United States and Southern Ontario. Ozone and pollutants that react to form ozone may originate from distances over 100 miles away and may be augmented by ozone that is formed by photochemical reactions of pollutants emitted locally. Consequently, control strategies being considered in Ontario must be compatible with strategies being developed in the United States.

Criteria for desirable ambient air were established for fluoridation rate on the basis of vegetation damage. Although annual phytotoxicology surveys have not detected more than trace damage to vegetation in a localized area of west Windsor, fluoridation rates in west Windsor and specifically in the Morton Dock area are significantly elevated and frequently exceed the criteria.

INTRODUCTION

The ambient air monitoring network operated by the Ministry of the Environment measures a number of pollutants that may be directly or indirectly adverse to health, vegetation, or the enjoyment of property. Monitors are often sited to indicate conditions in areas that are suspected of experiencing higher levels of air pollutants. When these areas achieve acceptable air quality, then other areas should also be acceptable. Monitors are also sited to provide information on the specific source of pollutants.

In addition to ambient air monitoring, the Ministry conducts phytotoxicology studies to determine the effect of air pollutants on vegetation. Also, inventories of emissions are maintained and utilized in mathematical models to predict levels of pollutants in the atmosphere. By utilizing the combined assets of these methods of evaluating air quality, the Ministry is able to determine trends in air quality and evaluate effects of existing and new sources of pollution.

MONITORING NETWORK DESCRIPTION

The Ministry of the Environment utilizes continuous and intermittent ambient air monitors located at fixed sites throughout the Windsor area. Monitoring is more intensive in the downtown area where emissions from automotive traffic and commercial establishments is more intense, and in west Windsor which is close to a heavily industrialized portion of Wayne County, Michigan and is where Ontario Hydro's J. C. Keith Generating Station is located.

During 1977 two new monitoring sites for suspended particulates were initiated to provide information concerning particulate levels further from the downtown and west Windsor areas. The locations of all Ministry monitoring stations in the Windsor Area are illustrated in Figure A of Appendix I and a verbal description of the locations and an indication of sampling elevations are provided in Table A of the same Appendix.

The various pollutants monitored at the different stations in Windsor are shown in Table B, Appendix I. Table C indicates the Ministry's criteria for desirable ambient air quality with respect to different pollutants as well as the prime basis for establishing these criteria.

In addition to the monitoring program of the Ministry of the Environment, monitoring of sulphur dioxide is carried out at Windsor by Ontario Hydro. Data obtained by Ontario Hydro are not included in this report but have been used to assess the quality of Ministry data and to attempt to locate sources of pollution.

The selection of 1972 as the base year for this report was governed by the amount of data available to establish trends in air quality and the consistency of air monitoring techniques.

METEOROLOGICAL DATA

Meteorological data are obtained from Ministry stations 12032 and 12034. At station 12032, located in west Windsor close to the Detroit River, wind speed and wind direction are measured at levels 7 metres and 30 metres above the ground.

Station 12034, located close to downtown Windsor and the Detroit River, collects the data utilized for the meteorological forcasting associated with the Air Pollution Index. These data consist of wind speed and wind direction measurements at the 10-metre and 46-metre levels, ambient temperature at the 10-metre level and the difference in ambient temperatures between the two levels.

The percentage of time when the winds were recorded to be blowing from various directions at the 30-metre level at station 12032 appears in Table D, Appendix II.

PARTICULATES

Particulates are emitted into the atmosphere by man, nature and the combined actions of man and nature. In the Windsor area primary sources of man-caused emissions are those originating from the iron and steel industry, foundry operations, fossil-fueled power generating plants and road traffic. Erosion of particulates by strong winds blowing across open fields, sand and coal piles, and smooth surfaces such as roadways and roofs, is a significant source of particulates resulting from the combined actions of man and nature.

Measurements for particulates are reported as dustfall, suspended particulates and soiling index. Dustfall is determined through the exposure of open cylinders (jars) of known diameter for 30 days and subsequently weighing the amount of particulate per unit area. Suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. Soiling index is measured by determining the difference between the amount of

light that is transmitted through a filter before and after ambient air is drawn through the filter for 1 or 2 hours. The amount of light transmitted through the filter is reduced by the quantity of particulates retained on the filter and is also affected by the size, shape, and opaqueness of the particulates. Soiling index is empirically related to suspended particulates in order to provide an immediate indication of the levels of suspended particulates without the time consuming laboratory analysis required for suspended particulate measurements.

To determine if there are excessive levels of specific constituents in suspended particulate matter, suspended particulate samples collected on filters were analysed for a variety of constituents. The results are discussed later in this section.

The following discussion of data for particulates indicates that much of Windsor experiences unsatisfactorily high levels of dustfall and suspended particulates. West Windsor, which is across the river from a heavily industrialized area of Wayne County, Michigan, and a localized area of East Windsor in the vicinity of the Casting Plant of Ford Motor Company of Canada, Limited are the areas most affected. Continuance of this Ministry's air monitoring program will provide an evaluation of the effectiveness of pollution control programs at Ford and in the Wayne County area.

Dustfall

The desirable ambient air criterion established for dustfall for a 30-day period is 7.0 milligrams of dustfall per square metre per 30 days ($mg/m^2/30$ days). The annual criterion is 4.5 $mg/m^2/30$ days averaged for 12 months.

These criteria have been established on the basis of historical data and standards developed by other enforcement agencies.

During 1977 the 30-day criterion was exceeded at 18 of the 21 monitoring sites where dustfall jars were located. The highest frequency of excursions above the criterion was 92 per cent. The annual average criterion was exceeded at 19 of the 21 monitoring sites during 1977. The areas that experience the highest dustfall loadings are the environs of the Casting Plant of Ford Motor Company of Canada, Limited, which is located south of Belle Isle in east Windsor, and west Windsor, largely attributable to sources in Wayne County. The dustfall values for 1977 appear in Table E, Appendix III. Figure B, Appendix III, presents the annual average dustfall values and the percentage of values above the monthly criterion for the various stations.

Dustfall levels have demonstrated a slight downward trend since 1972. This downward trend is exhibited by a decrease in the annual average for all monitoring sites as well as a decrease in the average percentage of values above the 30-day criterion. Table F and Figure C, Appendix III, illustrate the downward trend. It is evident from the marginal nature of the downward trend that in the near future the criteria for dustfall will not be achieved over much of Windsor unless the rate of downward trend is greatly increased.

Suspended Particultes

The two criteria for desirable ambient air quality with respect to suspended particulates are 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) measured over a 24-hour period and 60 ug/m^3 calculated as the annual geometric mean for 24-hour samples collected at a station

during 1 calendar year. The 24-hour criterion is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulate. The annual criterion is based on damage to property.

During 1977, filters were exposed to collect suspended particulates at 12 monitoring sites on an every sixth-day sampling frequency. The 24-hour criterion of 120 ug/m^3 was exceeded at all 12 monitoring sites with the percentage of samples above the criterion ranging from 6 to 40 per cent. The annual criterion of 60 ug/m^3, expressed as a geometric mean, was exceeded at 10 of the 12 monitoring sites.

Two new monitoring sites, stations 12036 and 12037, commenced operation in 1977. These stations were located farther inland from the Detroit River than other stations collecting suspended particulate samples. These locations were selected to determine the degree to which suspended particulate concentrations decrease as the distance from the industrialized portions of Wayne County, Michigan and downtown Windsor are increased. However, several years of data will be required before definite conclusions can be reached.

Since 1972 the levels of suspended particulates have decreased very appreciably. However, most of the decrease was achieved by 1975 and since 1975 suspended particulate levels have remained essentially constant as have the frequencies of excursions above the 24-hour criterion. Table G and Figure D, Appendix III illustrate the trend in data for suspended particulate.

An attempt was made to determine the effect of particulate emissions from the Windsor Casting Plant of the Ford Motor Company of Canada, Limited and from the heavily

industrialized area of Wayne County. Correlations between levels of suspended particulates and the number of hours of specific wind directions were determined. Figure E, Appendix III, illustrates the wind directions for which positive correlations were determined and the length of the arrows indicate the relative strength or magnitude of the correlations. The influence of the emissions of suspended particulates from the industrialized area of Wayne County is signified, in part, by the length of the arrows pointing towards that area from the different monitoring sites.

The two long arrows from the southwest and west-southwest at station 12013 illustrate to the influence of emissions from the Windsor Casting Plant of Ford Motor Company of Canada, Limited.

Figure F contains the annual geometric mean values for suspended particulates plus the percentage of values above the 24-hour criterion reported for the various monitoring stations during 1977. The 113 ug/m^3 annual geometric mean and the 40 per cent excursion frequency for the 24-hour criterion are the highest reported for the Windsor area and illustrate the localized effect of emissions from the Ford Casting Plant. The elevated values in west Windsor indicate the influence of emission sources in the industrialized downriver area of Wayne County. It is very evident from this figure that during 1977 air quality in much of Windsor did not meet the annual criterion of 60 ug/m^3 for suspended particulates.

Soiling Index

Criteria for desirable ambient air with respect to soiling index are a 24-hour average from midnight to midnight of 1.0 coefficient of haze (COH) per 1000 feet of air and an annual average of 0.5 COH per 1000 feet of air.

These criteria are based on adverse health effects created by suspended particulates in association with elevated levels of sulphur dioxide.

During 1977 unusual increases in soiling index values were detected at station 12008 located in downtown Windsor. Investigations revealed that a newer type of soiling index sampler, which was installed in November, 1976, gave higher readings than the previous model. Further investigation showed that instruments that operated on 2-hour sampling cycles yield lower soiling index values than instruments operated on a 1-hour sampling cycle. Two stations use 1-hour sampling cycles while six other stations use 2-hour cycles. These findings severely limit the interpretations that can be made for the data reported for the 8 monitoring sites in the Windsor area.

At station 12008, the newer 1-hour soiling index instrument was replaced by an older model in September, 1977. The increase in the annual average soiling index at station 12008 in 1977 is probably due to the higher values reported by the new instrument. Similarly the higher soiling index values reported for both stations 12008 and 12016 as compared to the other stations are attributable in the most part to the difference between the 1-hour instruments used at these stations versus the 2-hour instruments used at the other stations.

Summary data for soiling index are reported in Table H, Appendix III.

Chemical Analysis of Suspended Particulates

Between 1972 and 1977, a limited number of suspended particulate samples were analysed for nitrate, sulphate and the metals cadmium, chromium, copper, iron, lead, manganese,

nickel and vanadium. In 1971, similar analyses were conducted and due to the limited amount of data available a summary of the 1971 data is included with a summary of the more recent data in Table I, Appendix III.

Cadmium, nickel and vanadium have 24-hour criteria of 2.0 ug of metal per m^3 of air. The criteria for cadmium and vanadium are based on the protection of human health while the criterion for nickel was established for the protection of vegetation. There is a 24-hour criterion of 5.0 ug/m^3 of air for lead as well as a 30-day criterion for lead of 2.0 ug/m^3 expressed as a geometric mean. The criteria for lead are based on the protection of human health. There have been no criteria established for the other constituents of suspended particulates included in this section. The only excursion above any of the criteria was a 24-hour lead concentration of 5.8 ug/m^3 during 1971.

SULPHUR OXIDES

The combustion of sulphur-containing fuels and subsequent emissions of sulphur oxides in flue gases is the predominant source of man's contribution to sulphur oxides in the atmosphere. Therefore, primary emitters of sulphur oxides are fossil-fueled power plants and industries requiring large amounts of energy.

Sulphur oxides are measured in Windsor as gaseous sulphur dioxide, sulphate in suspended particulate matter, and as sulphation rate. Gaseous sulphur dioxide is measured continuously with analyzers utilizing coulometric technology. The sulphate content of suspended particulate matter is presented in the preceding section of the report. Sulphation

rate is a measurement of sulphur compounds oxidized to lead sulphate after contact with lead peroxide. Lead peroxide plates are exposed for periods of 30 days and then analysed for lead sulphate.

Sulphur Dioxide

Gaseous sulphur dioxide is monitored continuously at five separate locations in Windsor by the Ministry of the Environment. The data are reported as 1-hour concentrations, 24-hour concentrations calculated on a daily midnight-to-midnight basis, and annual average concentrations. The criteria for desirable ambient air are 0.25 parts of sulphur dioxide per million parts of air (ppm) during 1 hour, 0.10 ppm during 24 hours, and an annual average of 0.02 ppm. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion is based on the protection of human health.

There are two sulphur dioxide analysers in downtown Windsor at station 12008, four analyzers in west Windsor (one at stations 12015 and 12032 and two at station 12016), and one analyzer in east Windsor at station 12013. Backup analyzers are present at stations 12008 and 12016 to ensure continuity of the Air Pollution Index. The analysers at station 12008 record the effect on ambient air of emissions of sulphur dioxide from commercial establishments in the downtown core as well as the effect of more distant emissions such as those from industries and power plants located in Wayne County, Michigan. The analyzers in west Windsor reflect the emissions of sulphur dioxide from the heavy industrialized area of downriver Wayne County. These analyzers previously measured the effect of the emissions from the J. C. Keith Power Generating Station of Ontario Hydro prior to its shutdown in 1976 for re-modernization. The analyzer at

station 12013 is located in an area of Windsor where industries having minor emissions of sulphur dioxide are located and it reflects the effect of these emissions on ambient concentrations of sulphur dioxide.

During 1977 both the annual and 24-hour criteria were met for the first time at all Ministry stations where sulphur dioxide is monitored. The 1-hour criterion was exceeded once at stations 12014 and 12032 in west Windsor These excursions of the criterion occurred on May 20, 1977 and are believed to be primarily due to emissions from sources in Detroit that were subsequently brought under compliance with U. S. legislation. In previous years far more frequent excursions of the 1-hour criterion were noted. The improvement in ambient air quality with respect to sulphur dioxide and the essential achievement of the criteria for desirable ambient air quality in 1977 is attributed to the shutdown of the J. C. Keith Generating Station and significant improvements in emissions of sulphur dioxide from sources in Wayne County, Michigan. When the J. C. Keith Generating Station is re-commissioned sulphur dioxide emissions should be controlled to prevent significant effects on ambient air levels of sulphur dioxide. Table J, Appendix IV, presents a summary of levels of sulphur dioxide in Windsor from 1972 to 1977.

Pollution roses for sulphur dioxide were constructed by relating data for wind direction from station 12032 in west Windsor to sulphur dioxide. The roses pertaining to sulphur dioxide data for 1977 at stations 12008, 12013, 12015, 12016 and 12032 appear in Figure G, Appendix IV. The roses and a knowledge of emission inventories indicate slightly higher average concentrations of sulphur dioxide for winds blowing from the industrialized area of downriver Wayne County. However, levels of sulphur dioxide were satisfactory during 1977 indicating good control of sulphur dioxide emissions.

Sulphation Rate

The criterion for desirable ambient air quality with respect to sulphation rate is 0.7 milligrams of sulphate per 100 square centimetres of lead peroxide per day (mg SO_3/100 cm^2/day). The lead peroxide is exposed for 30 days and then a per day rate is computed. This criterion is based on the protection of vegetation and because most of the oxidizable sulphur compounds are normally in the form of sulphur dioxide the criterion is related hypothetically to the criterion of sulphur dioxide for annual average. However, in practice the relationship between annual average values of sulphur dioxide and sulphation rate has been weak. Sulphation rate is influenced by many varying factors such as meteorological conditions and therefore it is not a good indicator of trends in sulphur oxide levels.

Compared to most other monitoring techniques, sulphation rate does provide on an annual basis an inexpensive comparison of relative levels of sulphur oxides in a community. For example from Table K, Appendix IV, sulphation rates reported for stations 12015, 12016, 12032, 12035 indicate a greater abundance of oxidizable sulphur compounds in west Windsor than other areas of Windsor. The elevated levels in west Windsor are also illustrated in Figure H which shows the annual averages for sulphation rate and the percentage of values above the criterion during 1977. A year-to-year comparison of sulphation rates and percentage of values greater than the criterion (Table L) indicates an increase in oxidizable sulphur compounds that is not corroborated by the data for sulphur dioxide nor is the increase consistent with emission inventories for sulphur dioxide. This conflict emphasizes the unsuitability of utilizing sulphation rate as an indicator of temporal trends.

AIR POLLUTION INDEX

The Air Pollution Index (API) is used in seven Ontario cities as an alerting system to control or prevent an air pollution episode. Meteorological forecasting and current readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of high pollution conditions which are numerically reported as the API.

Data for sulphur dioxide are provided by a continuous monitoring instrument. Suspended particulate data are represented through a correlation between values for suspended particulates and soiling index. Hourly values of soiling index and sulphur dioxide are substituted into the following equation and the running average for 24 hours is reported as the API.

$$\text{1-hour API} = 0.78\ (18.26\ \text{COH} + 156.7\ SO_2)^{1.06}$$

where COH is soiling index expressed in coefficient of haze units

SO_2 is sulphur dioxide concentrations expressed in parts per million.

API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, constributors of major emissions are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. When the API reaches 100 all industries and other contributors of pollution not essential to public health and safety may be ordered to cease operations.

Although the API is based on the control of combined levels of sulphur dioxide and suspended particulates, emissions of other pollutants would be controlled simultaneously. However, situations may occur where the levels of certain pollutants such as ozone may be high and the API may be in the acceptable range. These conditions would be detected by the normal monitoring program of the Ministry.

In Windsor, the API is determined for station 12008, located downtown, and station 12016, located in west Windsor. The API value reported to the media is the higher value for the two stations. The meteorological data are supplied by station 12034 located on Riverside Drive, close to downtown.

During 1977, the API reached a maximum of 33 for eight consecutive hours on April 19. At all other times during 1977, the API was below 32 and therefore in the acceptable range. The slightly elevated readings on April 19 reflected poor dispersion conditions that resulted in high levels of suspended particulates throughout the area. The API values of 33 were determined from soiling index values provided by the newer design of soiling index monitor. As discussed in the section on soiling index, the newer designs of monitor yields higher values than the older design. It is unlikely that the Advisory Level would have been reached if the older design were used since API values using the older design would be generally 5 to 15 per cent less than values determined using the newer design.

The number of hours when the API has reached 32 has been reduced very significantly since 1972. In 1972, there were 181 hours 138 in 1973, 57 in 1974 and 0 in 1975 and 1976, and 8 in 1977. The 50 level of the API was reached for 5 hours in 1972, and there have been no values reaching 50 since that time.

CARBON MONOXIDE

Combustion processes emit the major proportion of man's contribution to carbon monoxide levels. Exhausts from motor vehicles are most critical due to their emissions originating at ground level and being most intense in downtown commercial areas where the public may be exposed for extensive periods. Industries and power-generating plants normally provide adequate dispersion for carbon monoxide emissions to prevent unsatisfactory levels in ambient air.

The criteria for carbon monoxide are 30 ppm for 1 hour and 13 ppm for any consecutive 8-hour period. These criteria are based on the protection of human health. For station 12008 there were no excursions reported above these criteria in 1977. Station 12008 is the only site in Windsor where carbon monoxide is monitored by the Ministry. Since it is located in the downtown area and there were no excursions above the criteria it is believed that most, if not all, areas of Windsor should have desirable ambient air quality with respect to carbon monoxide.

The annual average concentration for carbon monoxide was lower in 1977 than any previous year. Much of the decrease is likely attributable to improved monitoring capabilities resulting from the replacement of an obsolete and less accurate analyzer with a modern infra red gas analyzer. A summary of data for carbon monoxide from 1972 to 1977 appears in Table M, Appendix V.

A pollution rose for the relationship between levels of carbon monoxide at station 12008 and wind direction data for station 12032 was constructed to represent conditions in 1977. The pollution rose appears in Figure I, Appendix V. The average concentrations of carbon monoxide for the 16

wind directions ranged from 1.7 to 2.5 ppm, and for calm conditions was 2.8 ppm. The association of the highest average concentration with calm conditions suggests that during periods of poor dispersion, carbon monoxide levels are elevated by emissions from local sources such as motor vehicle exhausts.

OXIDES OF NITROGEN

Like several other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are the oxides of nitrogen of primary interest.

The chemiluminescence that is released from the reaction between nitric oxide in the air sample and ozone generated by the analyzer is measured to determine the concentration of nitric oxide. Oxides of nitrogen are measured by the same analyzer through the conversion of other oxides of nitrogen to nitric oxide and then analyzed for nitric oxide. Nitrogen dioxide is computed by subtracting the nitric oxide concentration from the total oxides of nitrogen concentrations. Therefore, it is assumed that there are negligible concentrations of oxides of nitrogen in the ambient air other than nitric oxide and nitrogen dioxide.

Criteria only exist for nitrogen dioxide. The criteria, which are based on the protection of human health and offensive odours, are 0.20 ppm for 1 hour and 0.10 ppm for 24 hours. Nitrogen dioxide is determined at station 12008 located in downtown Windsor. There have been no excursions reported above the criteria during the period 1972 to 1977. The annual average concentrations for nitric oxide and nitrogen dioxide have been very consistent. A summary of data for oxides of nitrogen appears in Table N, Appendix VI.

A pollution rose for nitrogen dioxide values reported for 1977 at station 12008 and data for wind direction from station 12032 is presented in Figure J, Appendix VI. From this pollution rose it is evident that nitrogen dioxide levels are relatively consistent for all wind directions although those values associated with winds from the south-southwest, southwest, and west-southwest are slightly higher than those values associated with other wind directions.

Notwithstanding that the criteria for nitrogen dioxide are not exceeded, oxides of nitrogen contribute to the formation of unsatisfactory levels of air pollution through their roles in the formation of photochemical oxidants. Photochemical oxidants are discussed later in this report.

HYDROCARBONS

Natural phenomena produce many hydrocarbons. The most abundant hydrocarbon present in ambient air is methane which is formed in large quantities by man-made and natural processes. Significant man-made sources of hydrocarbons are the incomplete combustion of organic and fossil fuels and losses due to evaporation during storage and transportation of hydrocarbons.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no desirable ambient air criteria have been established for total hydrocarbons. Instead, control is achieved by setting desirable ambient air criteria for specific hydrocarbons and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Total hydrocarbons are monitored continuously at station 12008 in downtown Windsor, utilizing flame ionization detection. Annual average concentrations for total hydrocarbon have ranged from 1.9 to 2.6 ppm for the years 1972 through 1977. This range of annual average concentrations is comparable with levels detected in the downtown areas of other cities. The annual average concentrations are listed in Table O, Appendix VII.

A pollution rose for total hydrocarbon appears in Figure K, Appendix VII. Average concentrations for specific wind directions are very uniform indicating the predominent effect of diffuse sources of hydrocarbon (emissions from motor vehicles in the downtown area) rather than point sources.

Hydrocarbons, especially non-methane or reactive hydrocarbons, are extremely important in photochemical reactions that produce photochemical oxidants. Means of controlling the emissions of hydrocarbons and the potential effect of such control on the formation of photochemical oxidants are being investigated. The role of hydrocarbon in the formation of photochemical oxidants is discussed more completely under Oxidants.

OXIDANTS

Oxidants in the ambient air are primarily a result of a series of photochemical reactions and inter-reactions involving oxides of nitrogen and hydrocarbons. When there is sufficient energy from sunlight, nitrogen dioxide is reduced to nitric oxide and an oxygen atom. The oxygen atom is capable of reacting with oxygen gas to produce ozone.

Ozone normally accounts for 80 to 95 per cent of the oxidants present in the ambient air. Although some nitric oxide may react with ozone to form nitrogen dioxide and oxygen gas thus reducing the concentration of ozone, some nitric oxide through photochemical reactions with hydrocarbons are converted to nitrogen dioxide or organic oxidants. Thus there is a net increase in nitrogen dioxide that may photochemically react to produce ozone.

Ozone is also present in the stratosphere where it plays the critical role of absorbing excessive amounts of ultra violet solar radiation that may be biologically harmful. Occasionally, ozone from the stratosphere may be transported downward to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Man-made sources contribute very significant proportions of the precursor chemicals that result in ozone formation (hydrocarbons and oxides of nitrogen). Motor vehicles are probably the most acute source. Nature contributes precursor chemicals through the emission of oxides of nitrogen from soils and reactive hydrocarbons from such sources as trees and plants.

Long range transport of ozone and its precursor chemicals may account for a major portion of local levels of ozone. Long-range transport from distances greater than 100 miles have been reported in the literature. Therefore, successful control of oxidants will depend on control strategies implemented in the United States and it will be important that control strategies being evaluated for Ontario are compatible with those across the border.

Oxidants are measured and reported as ozone because the vast majority of the photochemical oxidants present in ambient air is in the form of ozone. Also the monitoring

technology utilized to determine ozone levels is more accurate and efficient than techniques used to monitor total oxidants. An analyzer, located at station 12008 in downtown Windsor, determines the amount of chemiluminescence produced by reaction between ozone in the air sample and ethylene supplied through the analyzer.

The criterion for desirable ambient air with respect to ozone is 80 parts per billion (ppb) averaged for 1 hour. The criterion was established for the protection of human health and vegetation. Some detrimental health effects associated with elevated levels of photochemical oxidants are eye irritation and a decrease in the performance of atheletes.

During 1977 an error in the calibration procedure for ozone was detected. The error resulted in erroneously high concentrations being reported for 1976 (Ambient Air Quality in Windsor 1972 to 1976) and part of 1977. The error was such that ozone data could be adjusted. The summary of data for ozone contained in Table P, Appendix VIII is based on the adjusted data.

The annual average concentration for ozone has increased each year since 1974 as has the percentage of values above the 1-hour criterion. These increases may be attributed to a greater occurrence of meteorological conditions favourable for photochemical reactions. Due to the complexity of the photochemical reactions and inter-reactions as well as the long range transport of ozone and its precursor chemicals it is not possible to attribute the increases to any specific cause.

A pollution rose (Figure L, Appendix VIII) relating the percentage of the ozone concentrations above the 1-hour criterion to wind direction, reveals a strong association

with southerly winds. This association is likely due to the warmer summer weather that often accompanies southerly winds and the long range transport of ozone and its precursor chemicals from major centres in the United States.

A pollution rose (similar to those presented for other pollutants) is not presented for average concentrations of ozone determined during 1977. This type of pollution rose has not been included because most elevated values of ozone occur in the summer months when there is sufficient energy from sunlight to promote photochemical reactions and any pattern of elevated levels with respect to wind direction would be masked by the lower values that tend to occur in colder months.

Phytotoxicology surveys to determine the extent of vegetation damage due to photochemical oxidants are conducted on an annual basis. Each year oxidant damage to crops has been detected. A discernible trend in the extent of damage has not been found. Aside from the concentration of ozone, damage to vegetation is dependent on many other factors such as the type of vegetation, age of vegetation, soil conditions and meteorological factors such as rainfall and humidity.

FLUORIDES

Fluoride sources in the Windsor area are the steel industry located in the downriver area of Wayne County, Michigan, power plants whose coal contains trace amounts of fluorides, the unloading of fluorspar from ships into trucks in west Windsor and the subsequent trucking of the fluorspar to a plant south of the immediate Windsor area.

Fluoridation rate is a measurement designed to indicate the quantity of fluoride gas in the air. One hundred square centimetres of lime-impregnated filter is exposed to ambient air for thirty days and then analysed for fluoride content. This technique is relatively inexpensive compared to other techniques for measuring fluoride levels. It provides data that illustrate the relative amounts of gaseous fluorides in different areas. However, fluoridation rate is not a good indicator of temporal trends in levels of gaseous fluorides because many variables independent of average concentrations influence the reaction between gaseous fluoride and the lime filter.

The criteria for desirable ambient air with respect to fluoridation rate are based on vegetation damage. Consequently, there is a criterion established for the growing season from April 15 to October 15 of 40 micrograms (ug) of fluoride per 100 cm^2 of filter per 30 days as well as a criterion of 80 ug F/100 cm^2/30 days for the period of October 16 to April 14. Since the months of April and October are common to both criteria, excursions above the criteria during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days).

Fluoridation rates for 1977 appear in Table Q, Appendix IX. A summary of the data for fluoridation rates is presented in Table R, Appendix IX. It is very evident from this summary that fluoridation rates at stations 12032 and 12035, located in west Windsor, have reported higher values than other stations in Windsor. Also, stations 12015 and 12016, which are also located in west Windsor, report elevated values for fluoridation rate.

The annual average for fluoridation rate during 1977 at station 12032 was much higher than in previous years and although fluoridation rate is not considered a good

indicator of trends, the appreciable increase in the annual average at station 12032 should be carefully considered and reasons for the increase explored. A map showing the annual average values for fluoridation rate and the percentage of values above the criteria at the various sampling stations appears as Figure M in Appendix IX.

Since criteria for fluoridation rate are based on vegetation damage, judgements of the suitability of air quality will be dependent on the results of phytotoxicology surveys. Annual phytotoxicology surveys have not detected more than localized trace damage to vegetation attributable to fluorides in the Windsor area.

DISCUSSION

Monitoring of ambient air quality in Windsor will continue to demonstrate whether the criteria for desirable air quality for sulphur dioxide, carbon monoxide, and nitrogen dioxide are met. Also, ambient air monitoring will permit evaluations of the effectiveness of future pollution abatement measures designed to reduce the levels of particulates, ozone and fluorides.

Although the level of suspended particulates was appreciably higher in 1972 than in 1977 there has been essentially no improvement in suspended particulate levels since 1974 and there is some evidence of minor degradation. It is anticipated that a downward trend will be re-established through current programs to reduce particulate emissions in Wayne County, Michigan and at the Casting Plant of Ford Motor Company of Canada, Limited. The absence of excessive levels of metals in the suspended particulates somewhat reduces the urgency of the suspended particulate situation.

Also, the achievement of lower levels of sulphur dioxide reduces the synergistic action with suspended particulates and consequently reduces the potential for adverse health effects. Nevertheless, substantial reductions in suspended particulates are required to achieve satisfactory air quality in Windsor.

The occurrence of excessive levels of ozone in Windsor may only be appreciably reduced if compatible control strategies are developed and implemented throughout southern Ontario and neighbouring areas of the United States. These control strategies must be capable of reducing the quantity of precursor chemicals such that there will be less long-range transport of ozone and its precursor chemicals as well as a lesser quantity of ozone being formed as a result of local emissions of precursor chemicals. It is apparent that the ozone problem is very complex and will not be resolved in the immediate future.

Fluoride, as measured by fluoridation rate, has been elevated in the Morton Dock area of west Windsor since 1972. Levels determined in 1977 were higher than those of previous years. However, the criteria for desirable ambient air with respect to fluoridation rate are based on vegetation damage and there has not been a significant amount of vegetation damage detected during annual phytotoxicology surveys. This suggests that, although the criteria are exceeded, current levels are generally satisfactory. Nevertheless, an effort to determine the source of the fluorides should be made and if possible, emissions controlled in order to reduce the potential for vegetation damage.

The routine ambient air monitoring program does not normally address odours, localized effects from emissions of particulates, or complex organic pollutants. The offensiveness of odours is very subjective and there is no simple and effective method of routinely monitoring for odours.

Consequently, odour complaints are investigated and assessed by Ministry staff from the Windsor District Office.

Sometimes special monitoring is conducted to evaluate the localized effects from emissions of particulates. This information is then utilized in determining the extent of corrective action required. Also, special monitoring may be conducted to determine the existence of more exotic pollutants such as complex organics. However, since this type of monitoring is not part of the routine program, the findings are excluded from this and other reports concerning routine monitoring of ambient air quality in southwestern Ontario.

APPENDIX I

MONITORING NETWORK

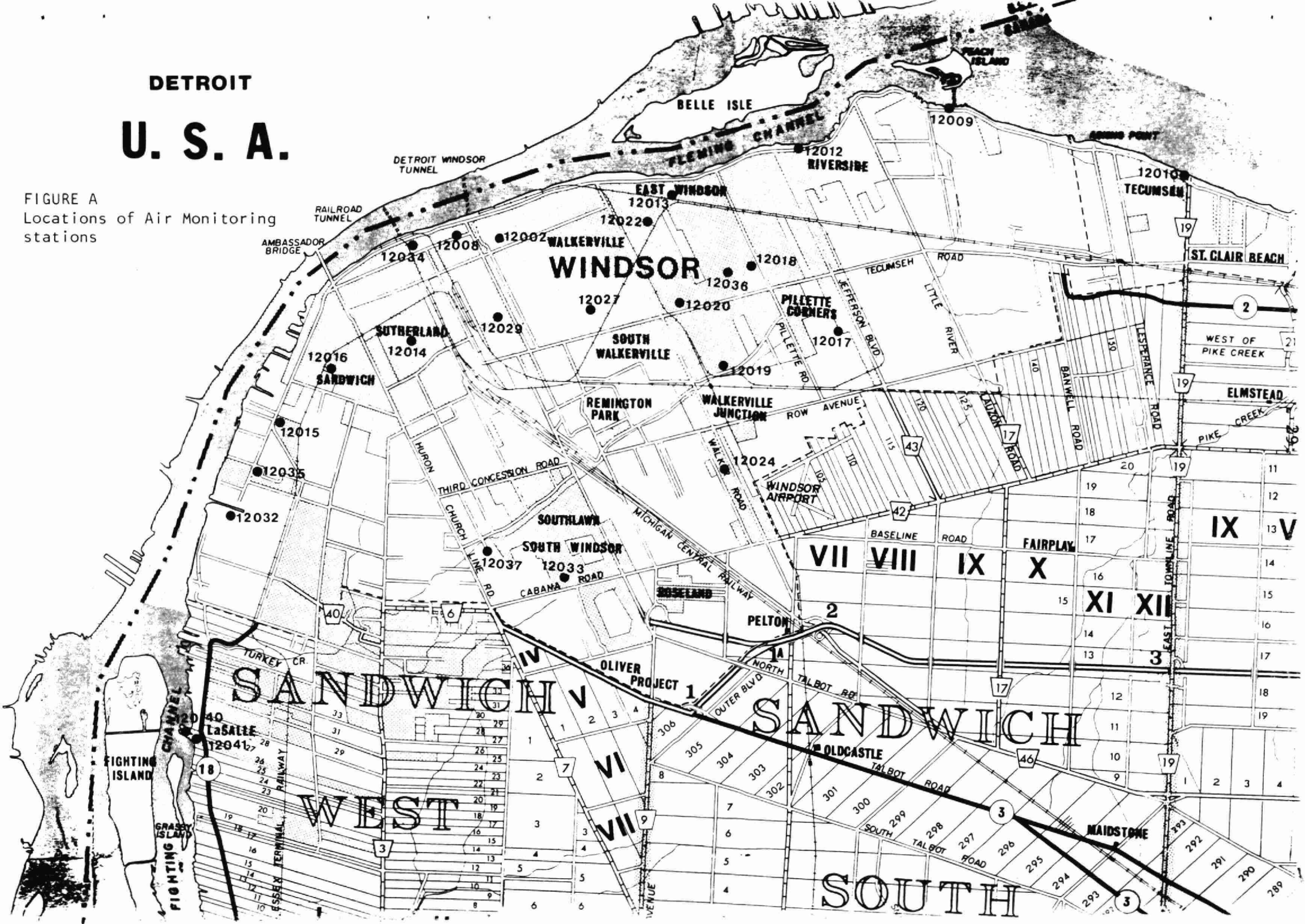


FIGURE A
Locations of Air Monitoring stations

Table A - Locations of Air Monitoring Stations

STATION NUMBER	LOCATION	UNIVERSAL TRANSVERSE MERCATOR PROJECTION CO-ORDINATES	ELEVATION ABOVE SEA LEVEL (METRES)	AIR INTAKE HEIGHT (METRES)
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12012	7007 Riverside Drive East	03385 - 46882	176	4
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12014	College/California Street	03304 - 46849	185	1
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12017	5066 Joinville Street	03388 - 46850	183	5
12018	W. P. Herman Collegiate	03372 - 46858	183	5
12019	Somme/Alexis Street	03369 - 46842	183	5
12020	1869 Albert Street	03363 - 46854	183	5
12022	Hickory/Richmond Street	03352 - 46870	183	5
12024	Byng/Seymore Street	03369 - 46820	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12029	459 Ellis West	03323 - 46853	185	5
12032	Morton Dock	03271 - 46817	175	4, 7 & 30
12033	3501 Longfellow	03335 - 46801	183	5
12034	C. P. Telecommunication Tower	03308 - 46868	175	10 & 46
12035	Healy/Sandwich	03276 - 46826	175	5
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12040	225 Willow Drive (La Salle)	03261 - 46774	175	5
12041	170 Willow Drive (La Salle)	03263 - 46773	175	5

Table B - Parameters Monitored in the Ambient Air in Windsor During 1977

STATION NUMBER	AIR POLLUTION INDEX	CARBON MONOXIDE	DUSTFALL	FLUORIDATION RATE	HYDROCARBONS	METEOROLOGICAL DATA	NITRIC OXIDE	NITROGEN DIOXIDE	NITROGEN OXIDES	OZONE	SOILING INDEX (COH)	SULPHATION RATE	SULPHUR DIOXIDE	SUSPENDED PARTICULATES
12002			X								X	X		X
12008	X	X	X	X	X		X	X	X	X	X	X	X	X
12009			X									X		X
12010			X								X	X		X
12012			X									X		X
12013			X								X	X	X	X
12014			X								X	X		X
12015			X	X							X	X	X	X
12016	X		X	X							X	X	X	X
12017												X		
12018												X		
12019			X									X		
12020			X									X		
12022			X	X								X		
12024			X									X		
12027			X	X								X		
12029			X									X		
12032			X	X		X					X	X	X	X
12033			X									X		
12034						X								
12035			X	X								X		
12036														X
12037														X
12040			X	X								X		
12041			X									X		

Table C - Desirable Ambient Air Quality
Criteria Established by the Ontario Ministry
of the Environment

Parameter	Desirable Ambient Air Quality Criteria	Prime Reasons for Establishing Criteria or Monitoring Parameter
Carbon Monoxide	30 ppm during 1 hour	Protection of human health
	13 ppm during 8 hours	Protection of human health
Dustfall	7 grams/meter^2 in 30 days	Historical and in keeping with other control agencies
	4.5 grams/meter^2 (monthly average in 1 year)	
Fluoridation Rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non growing season)
Hydrocarbons (Total)	NONE	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Nitric Oxide	NONE	Reacts with oxygen to produce NO_2
Nitrogen Dioxide	0.20 ppm during 1 hour	Protection of human health and protection against odours
	0.10 ppm during 24 hours	Protection of human health and protection against odours.
Oxides of Nitrogen	NONE	
Ozone	0.08 ppm during 1 hour	Protection of vegetation and human health

Table C - continued

Parameter	Desirable Ambient Air Quality Criteria	Prime Reasons for Establishing Criteria or Monitoring Parameter
Soiling (co-efficient of haze - COH)	1.0 COH per 1000 ft. of air averaged for 24 hours	Based on health effects in combination with SO_2
	0.5 COH per 1000 ft. of air averaged for 1 year	Based on health effects in combination with SO_2
Sulphation Rate	0.7 mg of SO_3 per 100 cm^2 of lead peroxide per day	Serves to measure relative amount of sulphur oxides over extensive periods of time thus permitting comparisons to annual average concentrations
Sulphur Dioxide	0.25 ppm during 1 hour	Protection of vegetation
	0.10 ppm during 1 day (24 hours)	Protection of human health
	0.02 ppm during 1 year	Protection of vegetation
Suspended Particulates	120 ug/m^3 during 24 hours	Based on impairment of visibility and health effects
	60 ug/m^3 (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in Suspended Particulates	2.0 ug/m^3 during 24 hours	Based on protection of human health
Lead in Suspended Particulates	5.0 ug/m^3 during 24 hours	Based on protection of human health
	2.0 ug/m^3 as a geometric mean over a 30 day period	Based on protection of human health
Nickel in Suspended Particulates	2.0 ug/m^3 during 24 hours	Based on protection of vegetation
Vanadium in Suspended Particulates	2.0 ug/m^3 during 24 hours	Based on protection of human health

APPENDIX II

METEOROLOGICAL DATA

Table D - Average Freuency of
Wind Direction Expressed
as Percentage

Station No. 12032 (Morton Dock) - WIND DIRECTION AT 30-METRES

WIND DIRECTION	YEAR					
	1972	1973	1974	1975	1976	1977
North	9.0	13.0	7.3	6.8	9.7	8.8
North East	11.2	10.7	10.3	10.6	8.8	10.1
East	11.3	11.2	8.5	10.6	8.3	8.6
South East	8.6	7.8	7.0	8.1	7.2	9.9
South	15.9	11.8	22.5	16.6	14.5	16.4
South West	15.0	19.2	16.7	19.4	16.2	20.8
West	14.7	13.9	14.6	15.6	20.2	16.0
North West	14.3	12.3	13.0	12.3	15.1	9.5

APPENDIX III

PARTICULATES

Table E - Dustfall Values for 1977
(mg/m^2/30 days)

Station Number	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average
12002	7.2	10.1	12.0	9.7	12.0	9.8	7.8	6.5	8.4	6.1	8.9	5.4	8.7*
12008	5.9	7.9	8.8	8.5	7.3	6.2	3.6	5.0	8.2	4.8	6.2	4.1	6.4*
12009	3.0	4.4	4.6	5.2	5.4	3.5	5.9	4.0	3.7	2.3	3.1	2.1	3.9
12010	16.3	4.4	5.7	N.D.	6.1	11.8	6.7	8.9	3.2	2.4	4.7	3.0	6.7*
12012	N.D.	4.1	5.6	2.4	5.8	5.2	4.5	4.2	4.6	2.8	4.8	2.7	4.2
12013	10.8	10.2	14.9	11.7	10.7	10.9	9.8	7.2	8.8	6.5	10.6	7.7	10.0*
12014	10.9	9.0	14.8	9.3	8.3	11.1	7.8	6.9	8.8	5.9	9.2	7.2	9.1*
12015	19.1	11.7	13.7	9.7	8.7	10.8	7.7	8.2	8.1	5.0	9.5	7.3	10.0*
12016	7.9	8.4	6.1	8.1	12.0	11.1	6.2	5.6	5.8	3.8	5.1	4.5	7.1*
12017	2.2	6.7	5.7	4.3	6.9	5.1	5.7	4.3	12.6	2.4	5.3	3.1	4.8*
12019	2.4	5.5	6.6	6.3	7.5	5.6	5.8	5.2	7.7	3.8	5.2	3.1	5.1*
12020	4.7	5.8	8.3	6.3	11.4	6.0	6.2	5.1	6.4	3.6	5.6	4.1	6.1*
12022	5.8	8.6	13.9	12.7	12.9	16.2	9.9	10.9	11.7	6.7	10.7	5.8	10.5*
12024	2.3	3.7	5.1	4.8	8.0	8.3	7.0	2.6	5.4	8.5	4.7	4.3	5.4*
12027	7.8	11.3	16.7	9.1	9.5	9.8	7.0	6.8	9.6	6.5	8.2	8.7	9.3*
12029	1.4	6.3	6.5	5.5	8.9	6.6	5.6	4.6	7.5	7.0	5.0	4.4	5.8*
12032	6.3	10.3	5.8	8.6	8.5	7.9	7.4	6.2	7.3	4.7	5.0	3.5	6.8*
12033	3.3	4.5	28.9	4.2	9.4	10.8	7.6	9.4	5.9	5.6	6.7	1.9	8.2*
12035	5.5	9.3	8.0	11.2	8.9	12.5	12.0	12.6	17.8	12.1	10.3	5.0	10.4*
12040	2.9	4.7	5.0	7.3	2.3	7.4	6.9	9.9	11.0	4.2	4.0	5.3	5.9*
12041	2.9	4.8	6.9	5.9	2.6	5.6	6.2	5.8	N.D.	3.8	4.6	6.0	5.0*

NOTE: (1) Underlined Values Exceed Monthly Criterion
(2) * - Denotes Values Exceeding Annual Criterion
(3) ND - No Datum

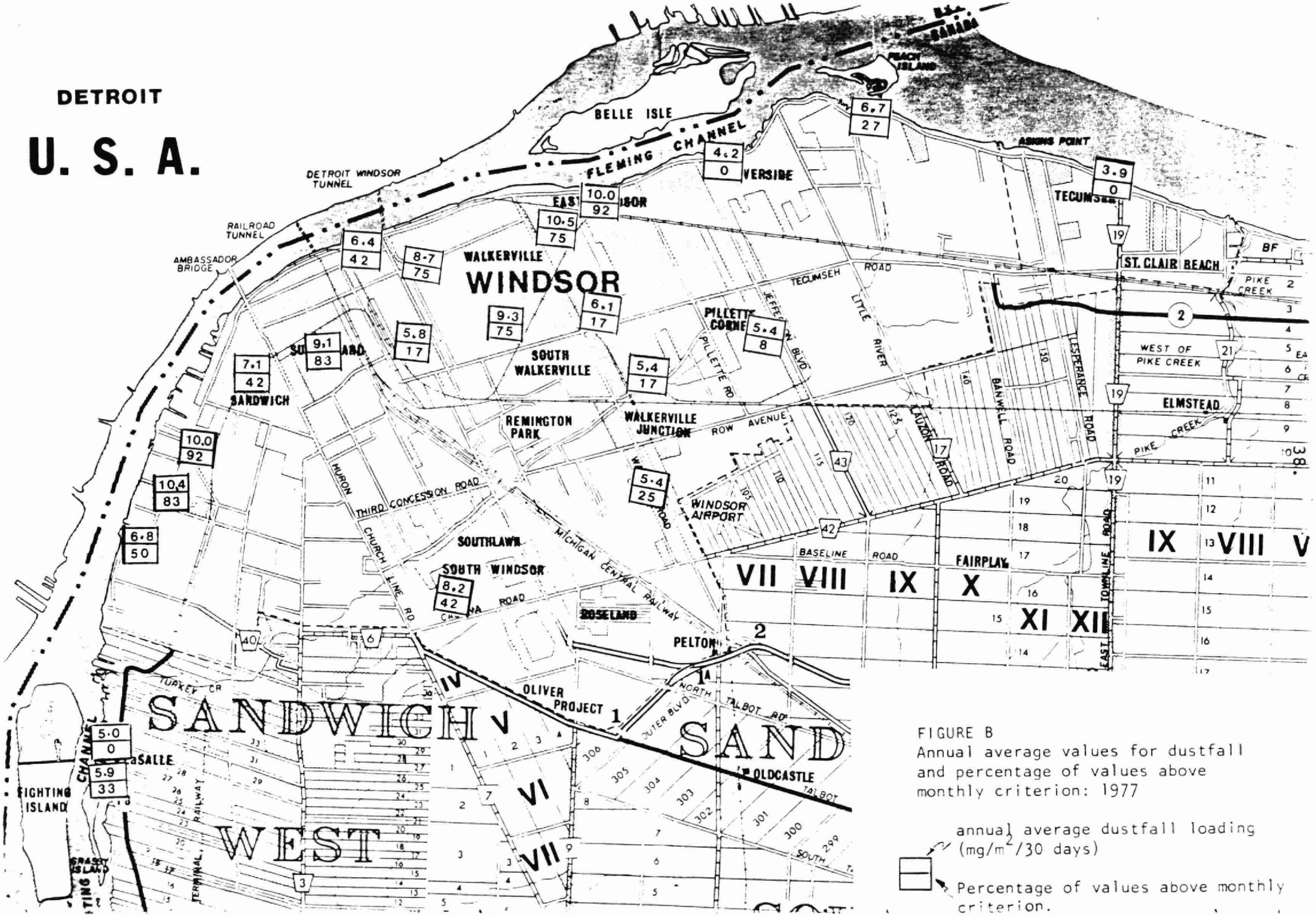


FIGURE B
Annual average values for dustfall and percentage of values above monthly criterion: 1977

annual average dustfall loading ($mg/m^2/30$ days)

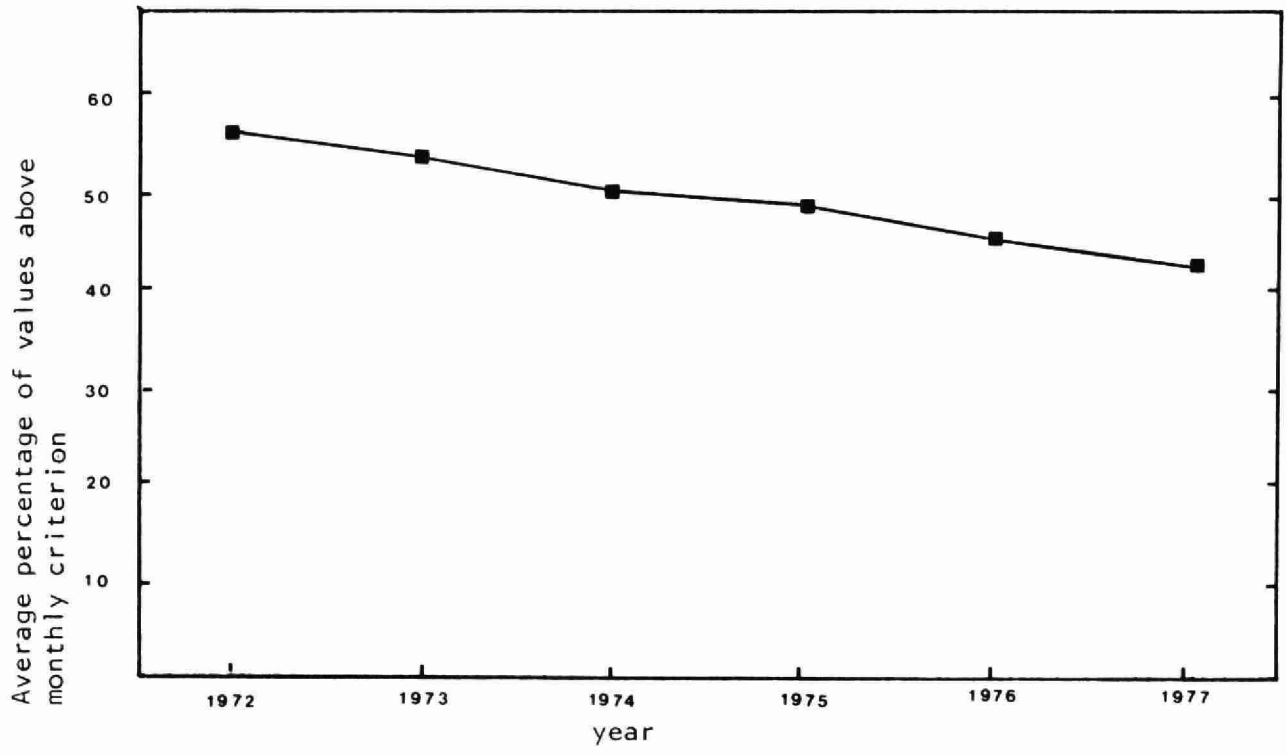
Percentage of values above monthly criterion.

Table F - Summary of Dustfall Values
From 1972 to 1977

	1972		1973		1974		1975		1976		1977	
STATION NUMBER	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE MONTHLY CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE MONTHLY CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE MONTHLY CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE MONTHLY CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE MONTHLY CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE MONTHLY CRITERION
12002	11.8	100	9.7	100	11.0	100	9.6	83	10.6	100	8.7	75
12008	8.1	50	8.6	75	11.1	82	8.2	58	7.4	33	6.4	42
12009	4.5	0	4.1	0	4.2	0	5.4	17	4.4	0	3.9	0
12010	6.1	33	8.3	50	10.2	36	5.7	11	6.6	36	6.7	27
12012	4.8	8	5.0	9	6.3	33	6.0	17	4.8	0	4.2	0
12013	10.2	92	10.6	75	10.6	75	8.9	83	9.6	83	10.0	92
12014	10.4	100	9.6	100	10.7	91	8.6	58	9.1	75	9.1	83
12015	15.3	100	11.0	100	15.2	100	12.7	100	13.0	92	10.0	92
12016	N O T	I N O P E R A T I O N					9.0	50	7.9	67	7.1	42
12017	4.7	17	3.9	0	3.8	9	6.5	38	4.8	0	5.4	8
12019	6.0	33	6.4	27	5.6	25	6.3	33	5.3	8	5.4	17
12020	6.9	42	7.3	50	6.6	33	6.5	17	7.1	42	6.1	17
12022	11.7	100	12.1	92	10.9	92	11.2	92	10.4	83	10.5	75
12024	5.9	17	5.3	17	5.7	8	5.5	27	5.7	20	5.4	25
12027	13.5	91	9.5	92	10.5	75	9.5	75	8.6	67	9.3	75
12029	8.7	75	7.2	42	6.8	27	6.6	17	6.1	33	5.8	17
12032	8.0	50	9.1	73	7.5	50	9.7	50	8.0	58	6.8	50
12033	5.6	18	4.6	0	4.8	17	4.9	8	6.1	17	8.2	42
12035	12.7	100	12.1	92	11.5	100	12.6	100	11.3	73	10.4	83
12040	8.5	58	8.0	50	7.0	50	8.1	50	7.1	42	5.9	33
12041	9.7	58	6.1	25	6.1	17	6.8	25	6.0	27	5.0	0
AVERAGES FOR STATIONS	8.7	57	7.9	54	8.3	51	8.0	49	7.6	46	7.1	43

NOTE: Annual average expressed in units of $mg/m^2/30$ days

FIGURE C - Trend in Dustfall Levels Based on Averaged Data from Twenty One Monitoring Stations: 1972 to 1977



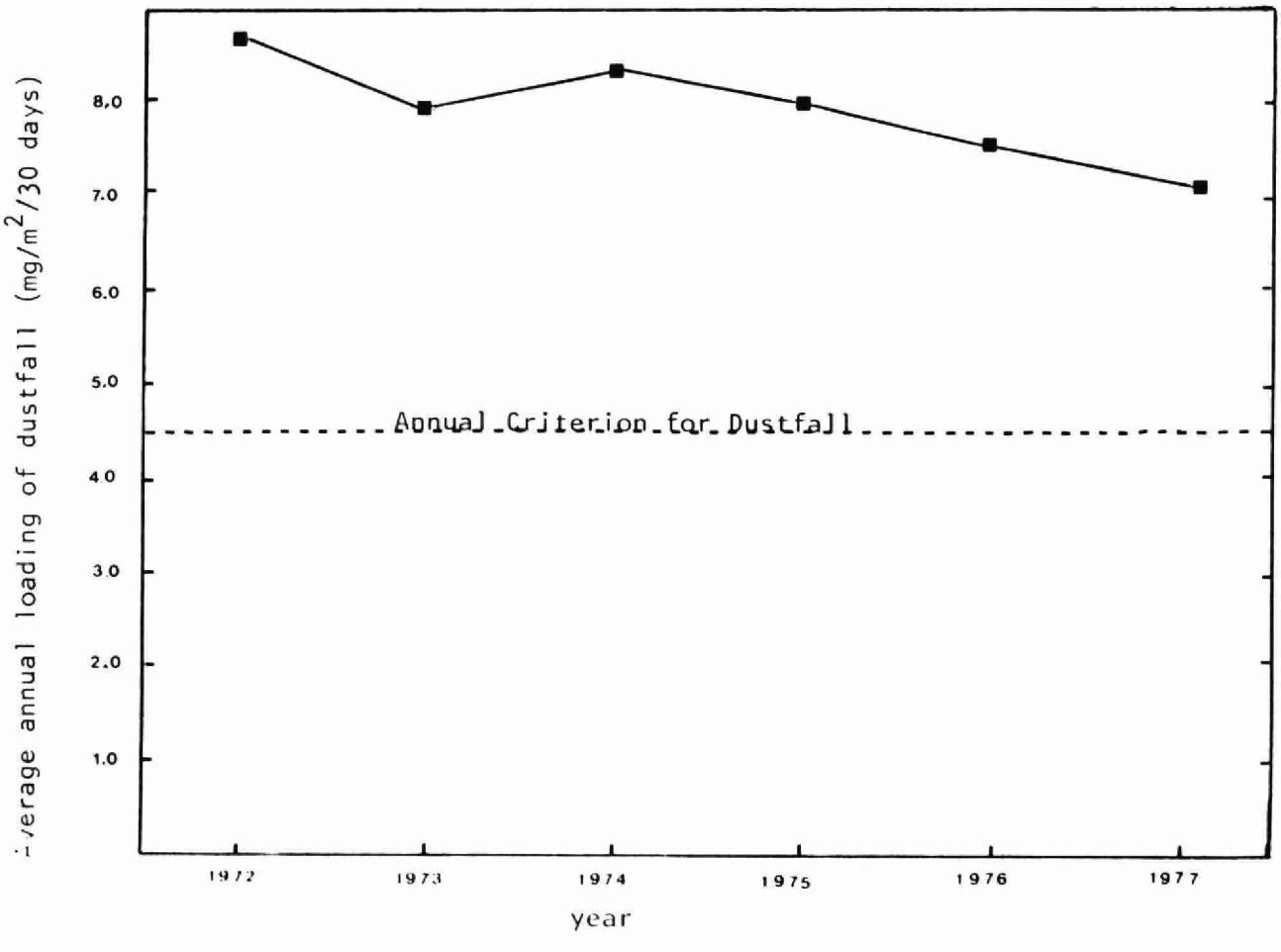
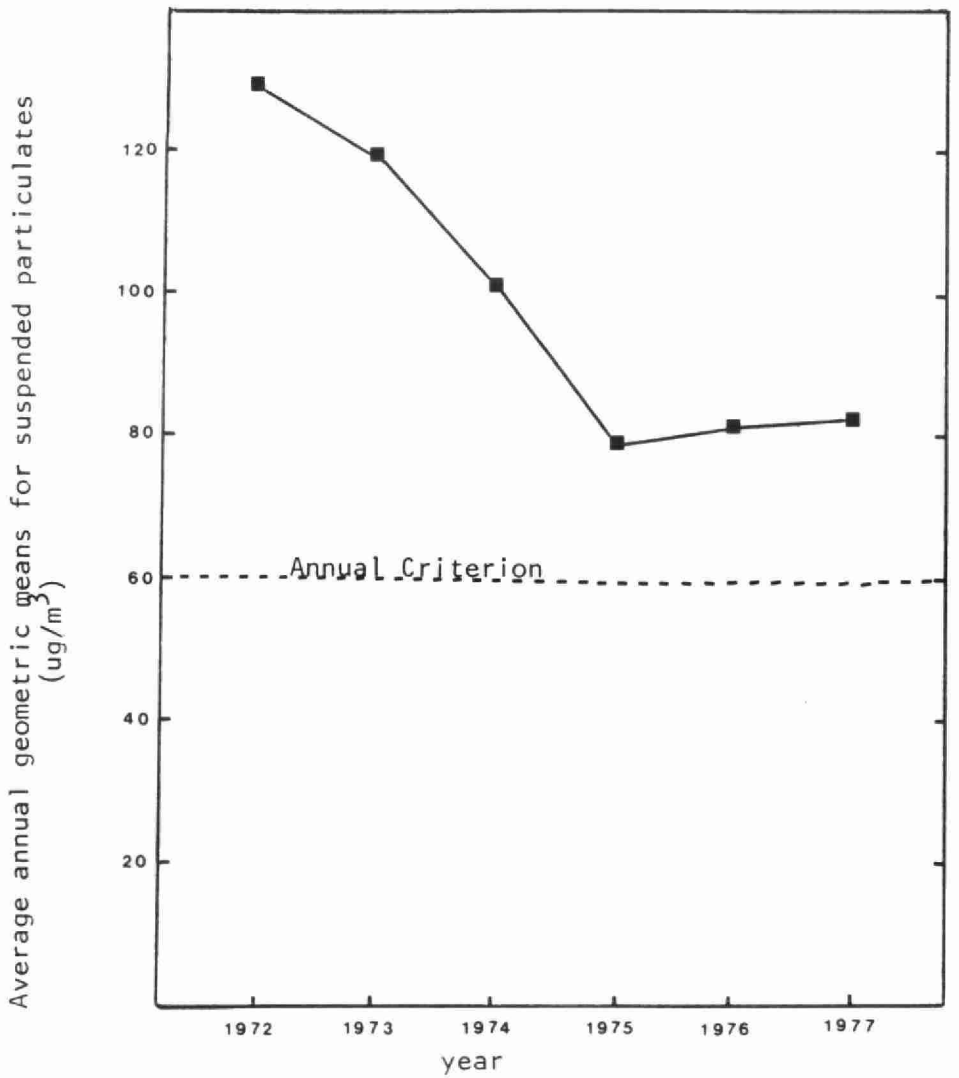


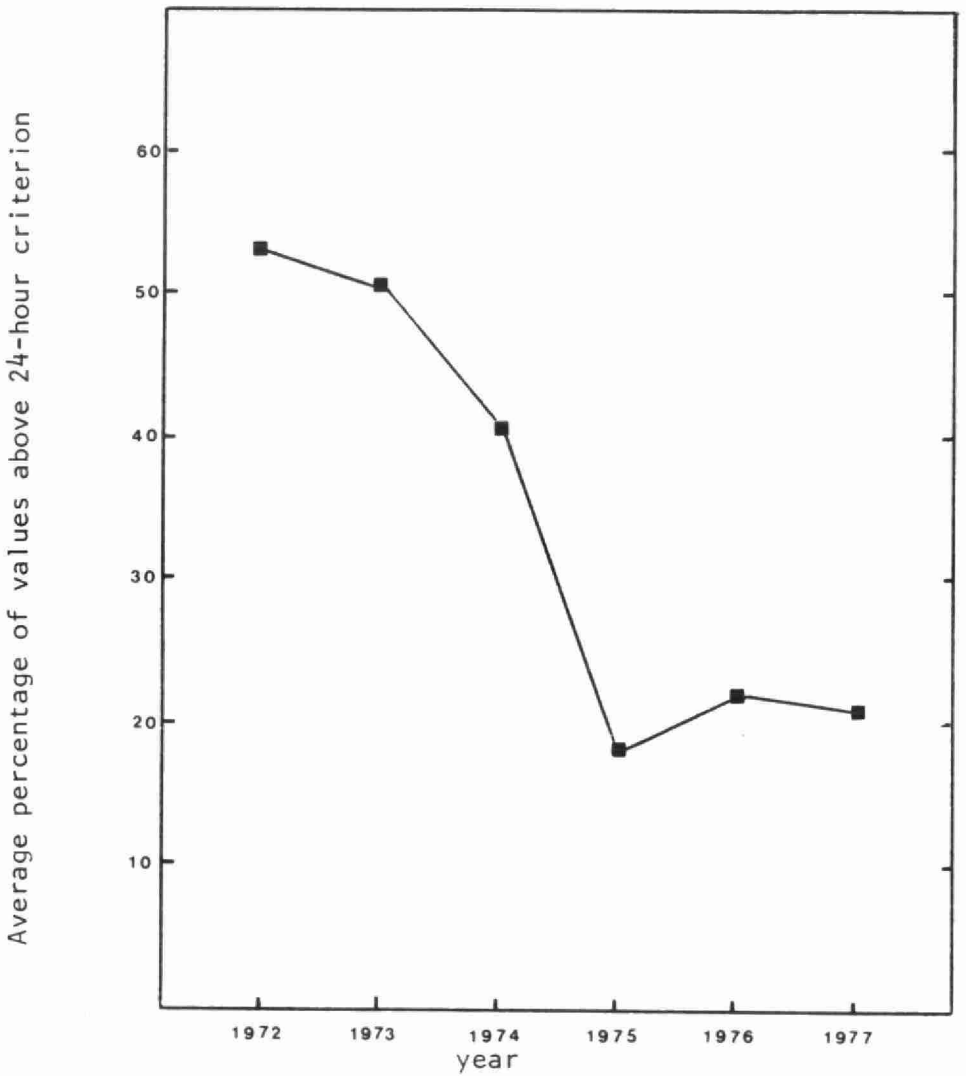
Table G - Summary of Suspended Particulate Levels in Windsor from 1972 to 1977

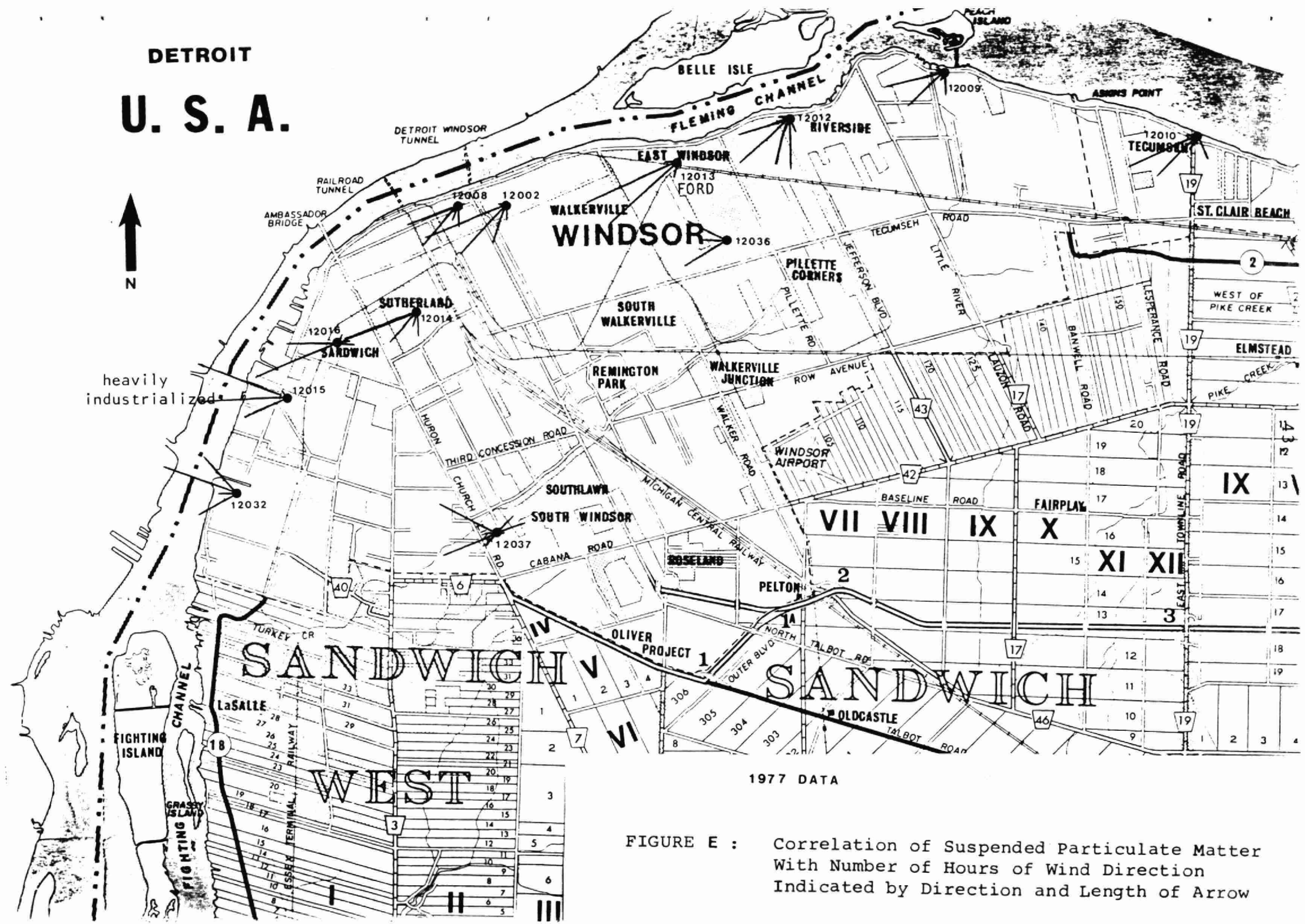
STATION NUMBER	1972 ANNUAL GEOMETRIC MEAN ug/m^3	1972 PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION	1973 ANNUAL GEOMETRIC MEAN ug/m^3	1973 PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION	1974 ANNUAL GEOMETRIC MEAN ug/m^3	1974 PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION	1975 ANNUAL GEOMETRIC MEAN ug/m^3	1975 PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION	1976 ANNUAL GEOMETRIC MEAN ug/m^3	1976 PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION	1977 ANNUAL GEOMETRIC MEAN ug/m^3	1977 PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION
12002	159	70	133	58	108	43	74	14	76	15	82	21
12008	126	57	126	55	116	47	82	17	80	19	87	24
12009	79	16	82	25	61	10	52	2	58	5	54	7
12010	85	23	86	27	58	17	46	2	54	10	47	6
12012	100	43	87	36	84	27	79	17	65	11	72	16
12013	151	65	145	69	113	44	89	26	98	37	113	40
12014	152	70	148	72	139	64	95	25	94	26	96	26
12015	183	80	147	66	152	84	105	33	113	42	93	25
12016	N O D A T A A V A I L A B L E						88	20	88	24	95	22
12032	126	53	120	53	94	30	81	21	89	27	93	25
12036	N O D A T A A V A I L A B L E										72	11
12037	N O D A T A A V A I L A B L E										67	10
AVERAGES FOR STATIONS	129	53	119	51	102	41	79	18	82	22	81 (83)*	19 (21)*

* Excluding values for stations 12036 and 12037

FIGURE D - Trend in Levels of Suspended Particulates Based on Averaged Data from Ten Monitoring Stations: 1972 to 1977







1977 DATA

FIGURE E : Correlation of Suspended Particulate Matter With Number of Hours of Wind Direction Indicated by Direction and Length of Arrow

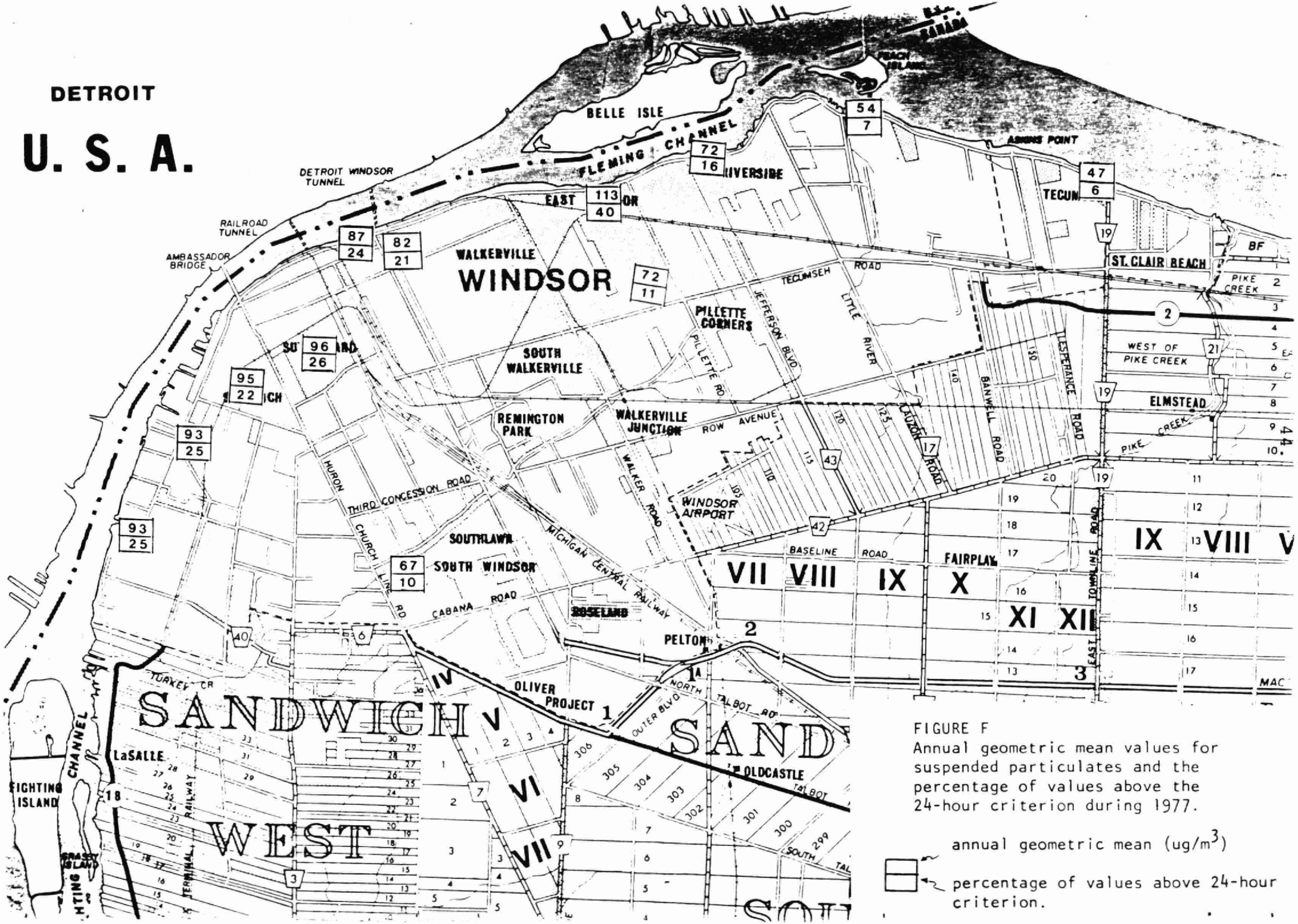


FIGURE F
Annual geometric mean values for suspended particulates and the percentage of values above the 24-hour criterion during 1977.

annual geometric mean (ug/m^3)

percentage of values above 24-hour criterion.

Table H - Summary of Soiling Index Levels (COH)
from 1972 to 1977

	1972		1973		1974		1975		1976		1977	
STATION NUMBER	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE 24-HOUR CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE 24-HOUR CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE 24-HOUR CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE 24-HOUR CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE 24-HOUR CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE 24-HOUR CRITERION
12002	INSUFFICENT DATA		0.4	2.7	0.4	0.3	0.2	0.3	0.3	0.0	0.2	0.0
12008*	0.5	3.3	0.5	2.5	0.4	2.0	0.4	1.4	0.5	1.7	0.6	2.3
12010	INSUFFICENT DATA		0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0
12013	NO DATA		NO DATA		0.4	0.6	0.3	0.8	0.4	1.2	0.3	0.6
12014	0.3	1.3	0.4	0.7	0.4	0.9	0.3	0.6	0.3	0.7	0.3	0.0
12015	0.5	6.6	0.5	3.2	0.4	0.3	0.4	0.7	0.4	1.2	0.4	1.2
12016*	NO DATA		NO DATA		NO DATA		0.4	0.6	0.5	1.4	0.5	1.1
12032	0.4	0.0	0.3	0.3	0.3	0.0	0.2	0.0	0.3	0.0	0.3	0.0
AVERAGE FOR STATIONS	0.4	2.8	0.4	1.6	0.4	0.6	0.3	0.6	0.4	0.8	0.4	0.7

* Soiling index sampler on 1-hour cycle; others on 2-hour cycle.

Table I - Summary of Constituents in Suspended Particulate Matter
1971 to 1977

(ug/m^3)

STATION AND YEAR	CADMIUM NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^m	CHROMIUM NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^m	COPPER NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^m	IRON NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^m	LEAD NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^m	MANGANESE NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^m
12002																		
1977	20	0.006	0.016	20	0.031	0.062	20	0.15	0.52	20	3.0	8.4	21	0.7	1.3	20	0.10	0.32
1976	12	0.002	0.010	12	0.006	0.022	12	0.10	0.36	12	3.3	8.2	12	0.7	1.1	12	0.12	0.22
1971	16	0.011	0.034	16	0.036	0.075	16	0.12	0.23	15	5.8	18.4	17	1.3	5.8	15	0.16	0.92
12008																		
1977	18	0.007	0.025	18	0.017	0.074	18	0.42	1.07	18	3.9	11.1	18	0.8	1.7	18	0.19	0.48
1976	15	0.000	0.003	15	0.012	0.029	15	0.25	0.45	15	3.2	6.9	15	0.6	1.3	15	0.11	0.28
1973	60	0.005	0.021				60	0.09	0.33				60	1.0	3.9			
1972	61	0.004	0.016				61	0.11	0.41				61	1.2	3.0			
1971	43	0.006	0.021	43	0.029	0.070	43	0.11	0.53	40	4.2	12.9	43	1.3	4.0	36	0.13	0.37
12010																		
1977	17	0.002	0.006	17	0.009	0.029	17	0.08	0.24	17	1.3	5.5	17	0.4	0.9	17	0.03	0.20
1976	12	0.001	0.006	12	0.007	0.026	12	0.12	0.52	12	1.6	5.2	12	0.3	1.0	12	0.05	0.19
1971	10	0.010	0.024	10	0.017	0.060	10	0.31	1.80	10	3.8	6.1	10	1.4	3.1	10	0.12	0.33
12013																		
1977	19	0.007	0.033	19	0.032	0.101	19	0.14	0.35	24	7.2	26.3	19	0.7	1.8	19	0.39	2.02
1976	17	0.006	0.035	17	0.028	0.113	17	0.14	0.28	22	5.7	21.9	17	0.6	2.0	17	0.38	1.94
1971	10	0.025	0.101	10	0.025	0.065	10	0.22	0.40	10	7.5	19.0	10	1.1	4.8	10	0.37	1.10
12014																		
1977																		
1971																		

Table I - continued

STATION AND YEAR	CADMIUM NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^{m}	CHROMIUM NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^{m}	COPPER NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^{m}	IRON NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^{m}	LEAD NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^{m}	MANGANESE NO. OF SAMPLES	CONCENTRATION AVERAGE	CONCENTRATION MAX^{m}
12015																		
1977										10	7.6	19.3						
1973	56	0.007	0.029	46	0.050	0.140	56	0.09	1.31	43	7.2	22.4	56	0.7	2.9	46	0.26	0.94
1972	54	0.008	0.019	53	0.033	0.143	54	0.10	0.21	53	15.9	129.7	54	1.0	2.2	53	0.34	3.19
1971	7	0.010	0.014	7	0.026	0.051	7	0.08	0.12	7	10.0	23.6	7	1.5	3.0	7	0.30	0.93
12016																		
1977										10	5.5	15.0						
12032																		
1977	26	0.002	0.009	26	0.015	0.048	26	0.34	1.13	25	3.8	17.9	26	0.4	0.9	26	0.11	0.62
1976	15	0.004	0.011	15	0.012	0.028	15	0.10	0.37	40	4.1	8.4	15	0.4	1.3	15	0.14	0.22
1971	10	0.015	0.029	10	0.023	0.057	10	0.13	0.42	10	5.3	9.4	10	0.9	1.9	10	0.16	0.31

CRITERIA FOR DESIRABLE AMBIENT AIR

2.0 ug/m^3/24 hours

5.0 ug/m^3/24 hours

2.0 ug/m^3/30 days as a geometric mean

Table I - continued

STATION AND YEAR	NICKEL NO. OF SAMPLES	NICKEL CONCENTRATION AVERAGE	NICKEL CONCENTRATION MAX[m]	NITRATE NO. OF SAMPLES	NITRATE CONCENTRATION AVERAGE	NITRATE CONCENTRATION MAX[m]	SULPHATE NO. OF SAMPLES	SULPHATE CONCENTRATION AVERAGE	SULPHATE CONCENTRATION MAX[m]	VANADIUM NO. OF SAMPLES	VANADIUM CONCENTRATION AVERAGE	VANADIUM CONCENTRATION MAX[m]
12002												
1977	20	0.025	0.073	56	4.8	21.6	56	12.4	35.5	20	0.03	0.14
1976	12	0.012	0.027	54	4.9	11.8	54	9.4	35.1	12	0.02	0.03
1971	16	0.052	0.138	15	5.7	14.8	15	17.9	52.9	12	0.06	0.30
12008												
1977	18	0.026	0.084	48	5.1	23.5	48	13.3	34.2	18	0.02	0.10
1976	15	0.050	0.409	105	4.8	21.6	104	10.6	39.7	15	0.17	1.47
1974	60	0.042	0.381							60	0.09	1.10
1972	60	0.051	0.241							61	0.08	0.96
1971	43	0.064	0.236	37	5.0	18.7	37	14.5	30.1	35	0.09	0.48
12010												
1977	17	0.022	0.035	52	4.3	24.5	52	10.3	25.4	17	0.00	0.02
1976	12	0.003	0.021	51	3.5	14.2	51	6.9	31.9	12	0.00	0.01
1971	10	0.037	0.108	10	3.9	7.7	10	13.3	20.5	10	0.01	0.04
12013												
1977	19	0.030	0.069	54	6.1	32.0	54	13.0	33.6	19	0.01	0.07
1976	17	0.004	0.029	59	4.4	15.0	59	8.2	21.0	17	0.01	0.02
1971	10	0.029	0.069	11	4.1	7.3	11	14.9	29.6	10	0.03	0.18
12014												
1977				65	5.3	25.1	65	14.5	28.1			
1971				6	4.6	8.1	6	11.2	19.3			

Table I - continued

STATION AND YEAR	NICKEL NO. OF SAMPLES	NICKEL CONCENTRATION AVERAGE	NICKEL CONCENTRATION MAX^{m}	NITRATE NO. OF SAMPLES	NITRATE CONCENTRATION AVERAGE	NITRATE CONCENTRATION MAX^{m}	SULPHATE NO. OF SAMPLES	SULPHATE CONCENTRATION AVERAGE	SULPHATE CONCENTRATION MAX^{m}	VANADIUM NO. OF SAMPLES	VANADIUM CONCENTRATION AVERAGE	VANADIUM CONCENTRATION MAX^{m}
12015												
1977				65	4.8	22.6	65	13.7	35.5			
1973	56	0.025	0.071							56	0.04	0.17
1972	55	0.042	0.086							54	0.04	0.11
1971	7	0.050	0.130	7	4.7	9.4	7	19.8	28.7	7	0.02	0.04
12016												
1977				63	5.4	28.0	64	15.1	63.9			
12032												
1977	26	0.015	0.060	61	6.2	32.0	61	15.2	35.0	26	0.01	0.06
1976	15	0.001	0.005	65	5.1	31.3	65	10.9	55.6	15	0.01	0.03
1971	10	0.023	0.050	11	3.7	6.9	11	11.3	27.3	10	0.01	0.04
CRITERIA FOR DESIRABLE AMBIENT AIR	2.0 ug/m^{3}/24 hours											

APPENDIX IV

SULPHUR OXIDES

Table J - Summary of Levels of Sulphur Dioxide
1972 to 1977

	STATIONS				
	12008	12013	12015	12016	12032
1977 Annual Average	0.02	0.01	0.02	0.02	0.02
Percentage of Values					
Greater Than 1-Hour	0.00	0.00	0.02	0.00	0.01
24-Hour	0.00	0.00	0.00	0.00	0.00
1976 Annual Average	0.03		0.02	0.02	0.02
Percentage of Values					
Greater Than 1-Hour	0.06		0.20	0.07	0.03
24-Hour	0.3		0.6	0.3	0.0
1975 Annual Average	0.03		0.01	0.02	INSUFFICIENT
Percentage of Values					
Greater Than 1-Hour	0.03		0.23	0.05	DATA
24-Hour	0.6		0.6	0.0	
1974 Annual Average	0.03		0.02	NO	0.02
Percentage of Values					
Greater Than 1-Hour	0.25		0.64	DATA	0.11
24-Hour	1.7		1.3		0.0
1973 Annual Average	0.03		NO	DATA	0.02
Percentage of Values					
Greater Than 1-Hour	0.36		NO	DATA	0.47
24-Hour	2.2		NO	DATA	1.6
1972 Annual Average	0.04		NO	DATA	0.03
Percentage of Values					
Greater Than 1-Hour	0.73		NO	DATA	0.06
24-Hour	3.6		NO	DATA	0.0

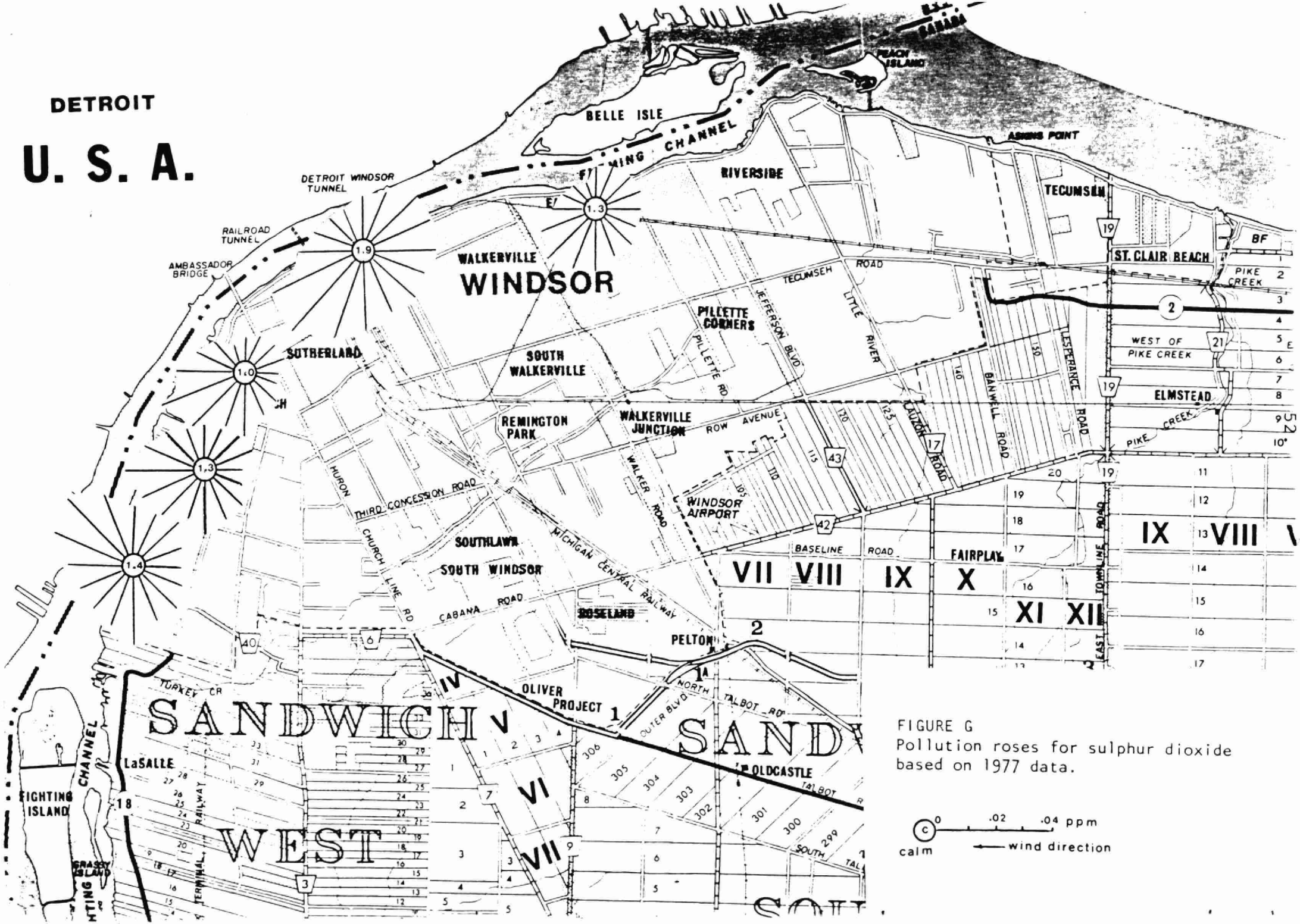


FIGURE G
Pollution roses for sulphur dioxide based on 1977 data.

calm 0 .02 .04 ppm
wind direction

Table K - 1977 Data for Sulphation Rate
(mg of SO_3/100 cm^2/day)

STATION NUMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL AVERAGE
12002	0.98	0.76	0.64	0.67	0.68	0.55	0.56	0.53	0.31	0.45	0.61	1.09	0.65
12008	1.30	0.48	0.40	0.40	0.38	0.43	0.43	0.10	0.21	0.38	0.39	ND	0.45
12009	0.70	0.82	0.76	0.55	0.64	0.54	0.53	0.37	0.41	0.52	0.62	1.24	0.64
12010	0.30	0.28	0.38	0.30	0.35	0.36	0.44	0.44	0.25	0.32	0.49	0.89	0.40
12012	1.16	0.80	0.68	0.60	0.71	0.46	0.58	0.32	0.36	0.42	0.56	1.15	0.65
12013	0.56	0.64	0.68	0.65	0.64	0.45	0.53	0.47	0.25	0.42	0.53	1.03	0.57
12014	0.93	1.06	0.86	0.77	0.75	0.69	0.76	0.10	0.41	0.55	0.87	1.48	0.77
12015	1.11	1.62	1.52	0.97	1.01	1.26	1.20	1.09	0.88	0.92	1.31	2.28	1.26
12016	1.11	1.76	1.22	0.85	1.21	0.88	0.85	0.85	0.65	0.85	1.25	2.28	1.15
12017	0.57	0.70	0.59	0.65	0.54	0.51	0.58	0.39	0.32	0.44	0.64	1.27	0.60
12018	0.70	0.76	0.64	0.57	0.61	0.39	0.50	0.42	0.26	0.32	0.62	1.12	0.58
12019	0.64	0.80	0.64	0.55	0.61	0.36	0.41	0.30	0.18	0.28	0.50	0.94	0.52
12020	0.52	0.70	0.60	0.54	0.57	0.44	0.49	0.30	0.26	0.38	0.53	0.96	0.52
12022	0.59	0.86	0.60	0.69	0.67	0.51	0.55	0.39	0.37	0.40	0.64	1.17	0.62
12024	0.46	0.48	0.56	0.37	0.41	0.25	0.37	0.32	0.23	0.25	0.41	0.72	0.40
12027	0.55	0.84	0.57	0.67	0.55	0.51	0.52	0.37	0.43	0.50	0.52	1.09	0.59
12029	0.93	1.10	0.79	0.85	0.74	0.59	0.69	0.85	0.60	0.72	0.77	1.50	0.84
12032	0.60	0.92	0.83	0.83	0.81	0.63	0.53	0.46	0.79	0.67	0.73	1.17	0.75
12033	0.57	0.74	0.83	0.68	0.72	0.41	0.50	0.36	0.32	0.41	0.46	0.93	0.58
12035	0.85	1.34	1.04	1.05	1.61	0.66	0.78	0.83	0.90	0.56	0.85	153	1.00
12040	0.59	0.52	0.60	0.57	0.61	0.38	0.49	0.25	0.31	0.41	0.52	1.03	0.52
12041	0.46	0.44	0.55	0.51	0.49	0.36	0.49	0.36	0.31	0.32	0.44	0.93	0.47

NOTE: (1) Underlined values exceed criterion for desirable ambient air quality (0.70 mg/100 cm^2/day)
(2) ND - No Datum

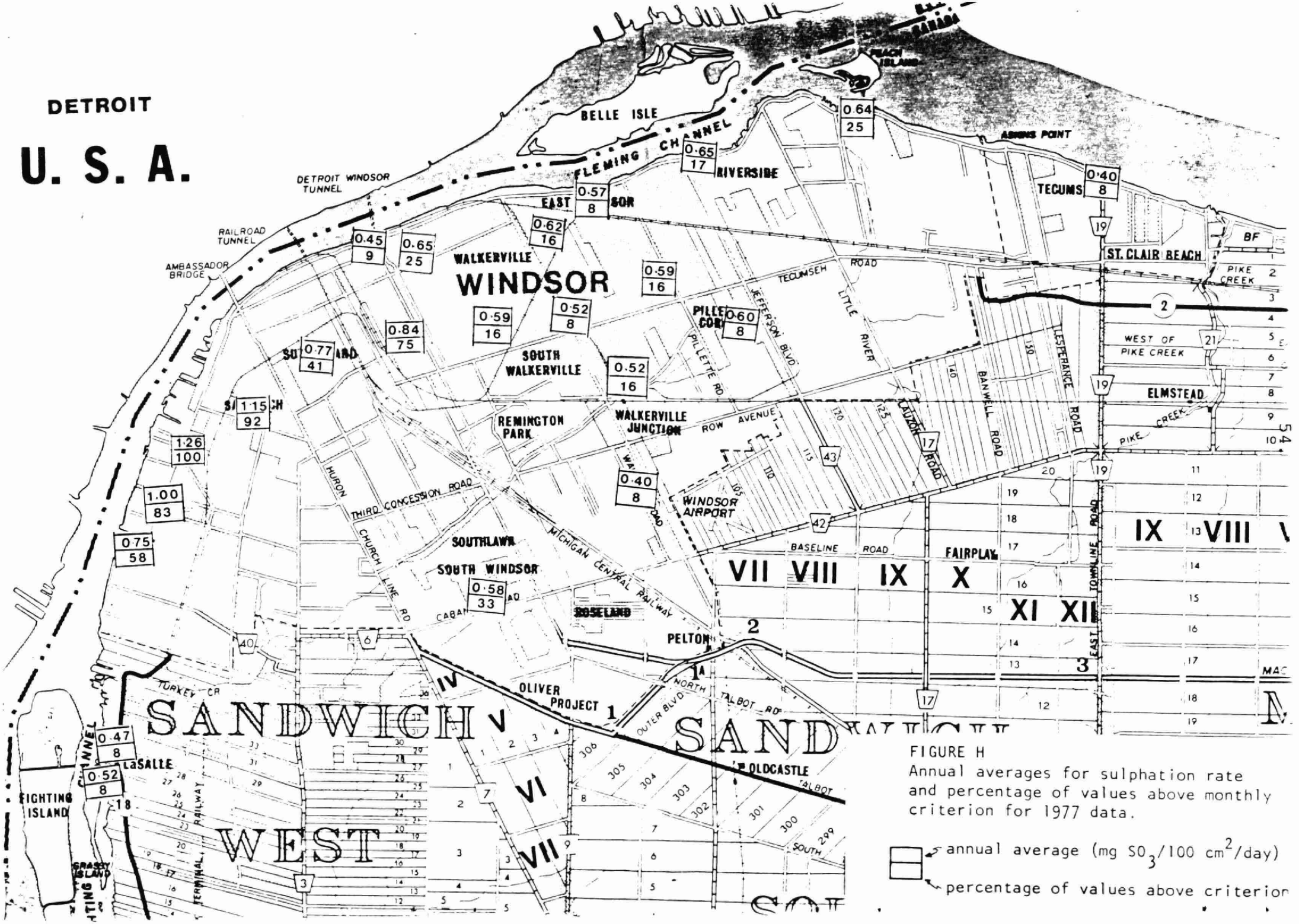


FIGURE H
Annual averages for sulphation rate and percentage of values above monthly criterion for 1977 data.

annual average (mg SO_3/100 cm^2/day)

percentage of values above criterion

Table L - Summary of Sulphation Rate Levels
in Windsor from 1972 to 1977

	1972		1973		1974		1975		1976		1977	
STATION NUMBER	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERION	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERION
12002	0.76	42	0.59	36	0.30	0	0.28	0	0.41	0	0.65	25
12008	1.47	82	1.11	50	0.68	42	0.47	18	0.47	27	0.45	9
12009	0.65	33	0.59	33	0.25	0	0.24	0	0.38	8	0.64	25
12010	0.34	0	0.32	17	0.13	0	0.14	0	0.18	0	0.40	8
12012	0.70	42	0.68	42	0.28	0	0.22	0	0.40	10	0.65	17
12013	0.64	42	0.56	9	0.26	0	0.25	0	0.37	0	0.57	8
12014	1.10	67	0.99	92	0.47	8	0.35	0	0.58	30	0.77	41
12015	2.06	100	1.91	100	0.85	50	0.57	18	1.03	90	1.26	100
12016	N O T I N O P E R A T I O N						0.50	14	1.00	90	1.15	92
12017	0.58	36	0.53	25	0.30	0	0.23	0	0.52	20	0.60	8
12018	0.62	42	0.42	20	0.25	0	0.24	0	0.43	0	0.59	16
12019	0.68	44	0.60	17	0.25	0	0.24	0	0.42	0	0.52	16
12020	0.58	42	0.51	8	0.24	0	0.24	0	0.40	0	0.52	8
12022	0.63	42	0.62	42	0.29	0	0.26	0	0.44	0	0.62	16
12024	0.43	25	0.38	8	0.20	0	0.18	0	0.32	0	0.40	8
12027	0.66	42	0.59	17	0.26	0	0.23	0	0.47	0	0.59	16
12029	0.87	42	0.88	64	0.39	0	0.34	0	0.56	20	0.84	75
12032	0.90	67	0.78	58	0.38	0	0.32	0	0.57	25	0.75	58
12033	0.66	36	0.55	25	0.28	0	0.27	0	0.42	0	0.58	33
12035	1.15	82	1.01	64	0.54	27	0.42	9	0.73	44	1.00	83
12040	0.61	33	0.49	8	0.25	0	0.24	0	0.42	0	0.52	8
12041	0.56	27	0.44	17	0.23	0	0.23	0	0.42	8	0.47	8

NOTE: Annual average expressed in units of mg SO_3/100 cm^2/day.

APPENDIX V

CARBON MONOXIDE

Table M - Summary of Data for Carbon Monoxide: 1972 to 1977

Year	Annual Average (ppm)	Percentage of Values Above 1-Hour Criterion	Percentage of Values Above 8-Hour Criterion
1977	2	0	0
1976	4	0	0
1975	5	0	0.32
1974	5	0	0.30
1973	5	0.01	0.10
1972	5	0	0

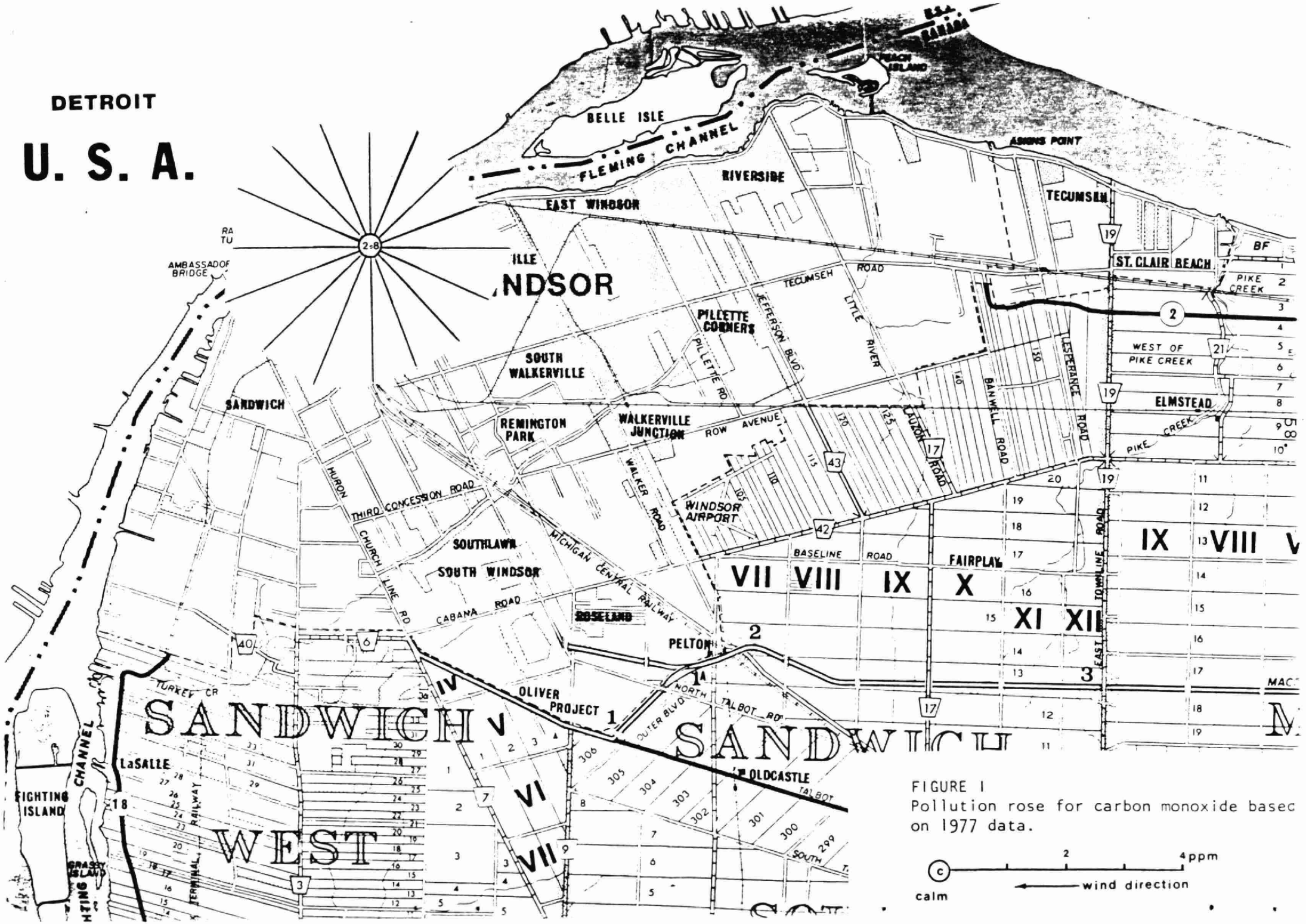


FIGURE 1
Pollution rose for carbon monoxide based on 1977 data.

APPENDIX VI

OXIDES OF NITROGEN

Table N - Summary of Data for Oxides of Nitrogen: 1972 to 1977.

Year	Annual Average (ppm) Nitric Oxide	Nitrogen Dioxide	Oxides of Nitrogen	Percentage of Values Greater Than Criteria for Nitrogen Dioxide for: 1-hour	24-hour
1977	0.03	0.03	0.07	0	0
1976	0.03	0.03	0.06	0	0
1975	*	0.03	0.05	0	0
1974	0.04	0.03	0.07	0	0
1973	ND	0.03	ND	0	0
1972	ND	*	*	0	0

ND - No Data
* - Insufficient data to compute annual average

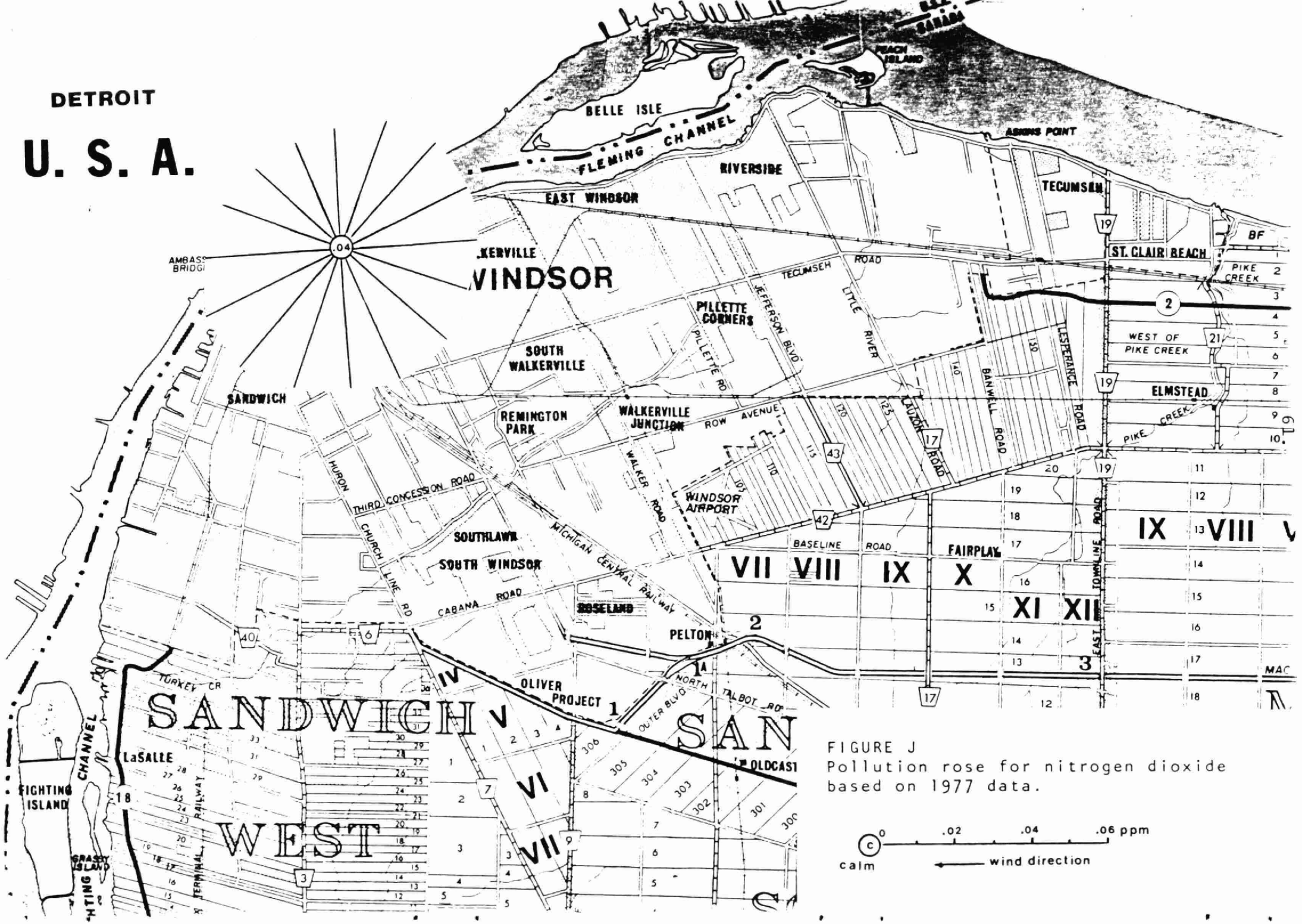


FIGURE J
Pollution rose for nitrogen dioxide based on 1977 data.

APPENDIX VII

TOTAL HYDROCARBONS

Table O - Summary of Data for Total Hydrocarbons: 1972 to 1977

Year	Annual Average (ppm)
1977	2.4
1976	2.6
1975	2.2
1974	1.9
1973	2.1
1972	2.2

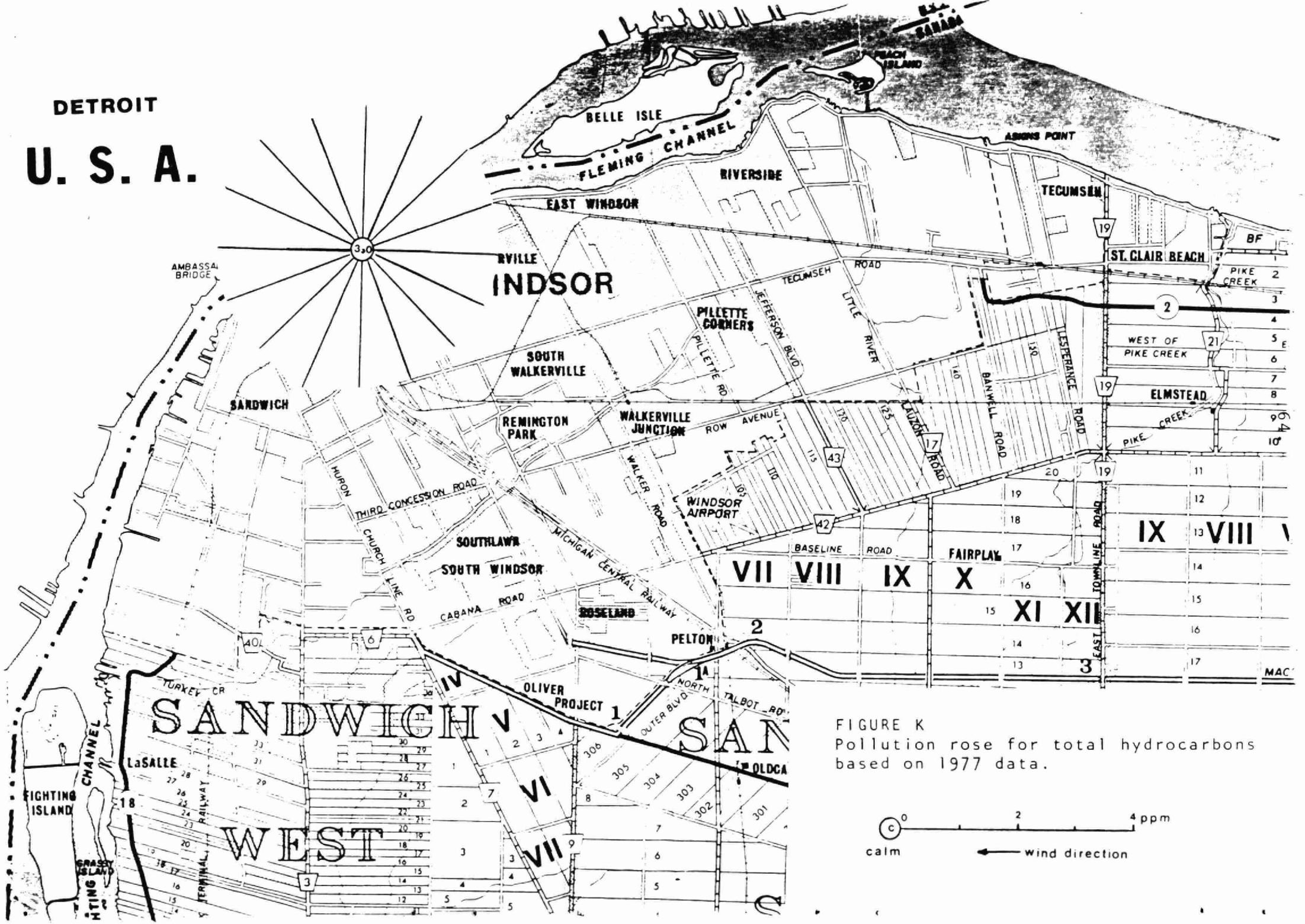


FIGURE K
Pollution rose for total hydrocarbons based on 1977 data.

APPENDIX VIII

OXIDANTS

Table P - Summary of Data for Ozone: 1974 to 1977

Year	Annual Average (ppb)	Percentage of Values Above 1-Hour Criterion
1977	21	3.0
1976	21	2.5
1975	17	2.2
1974	14	0.8

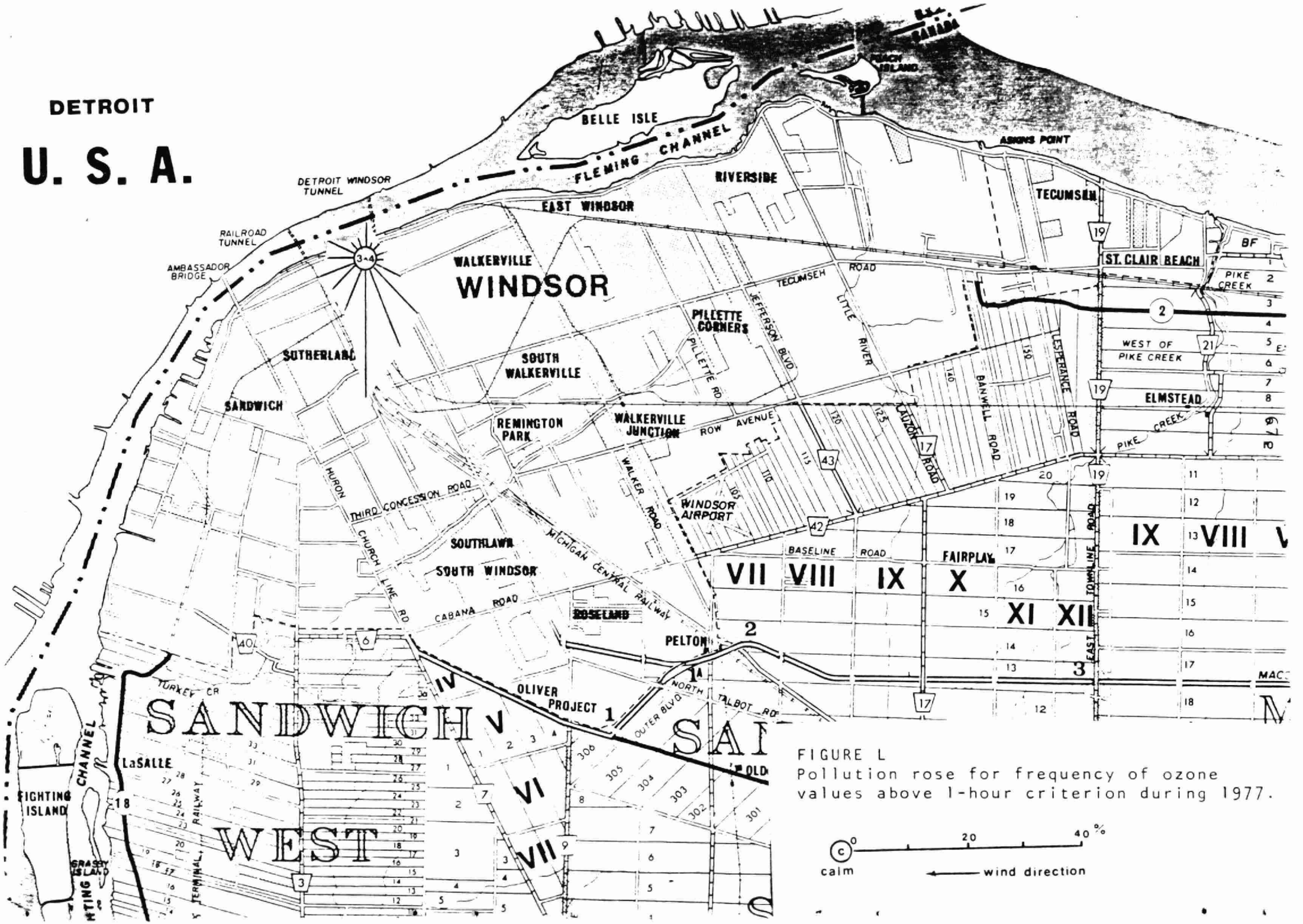


FIGURE L
Pollution rose for frequency of ozone values above 1-hour criterion during 1977.

APPENDIX IX

FLUORIDES

Table Q - Fluoridation Rates for 1977
(ug F/100 cm^2/30days)

STATION NUMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL AVERAGE
12008	62	40	72	25	38	29	47	36	40	44	31	54	43
12015	69	67	58	52	55	66	57	71	72	58	49	63	61
12016	72	52	41	56	51	57	55	54	46	51	46	54	53
12022	59	33	75	40	43	36	44	30	33	40	38	33	42
12027	49	28	51	30	45	34	47	23	26	32	29	39	36
12032	159	230	124	170	140	169	95	99	148	145	103	135	143
12035	98	94	61	99	97	42	63	96	124	129	56	60	85
12040	62	25	72	37	42	27	29	35	29	44	39	89	44

NOTE: Underlined values exceed criteria for desirable ambient air quality.

Table R - Summary of Fluoridation Rate Levels
in Windsor from 1972 to 977

(ug F/100 cm^2/month)

	1972		1973		1974		1975		1976		1977	
STATION NUMBER	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERIA	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERIA	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERIA	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERIA	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERIA	ANNUAL AVERAGE	PERCENTAGE OF VALUES ABOVE CRITERIA
12008	43	18	49	42	47	17	44	42	33	8	43	8
12015	79	75	75	75	73	75	66	50	56	25	61	42
12016	N O T I N O P E R A T I O N						60	56	47	25	53	42
12022	44	25	51	33	47	33	40	42	31	8	42	17
12027	38	8	41	25	42	8	27	8	24	0	36	17
12032	65	50	87	83	105	75	103	75	98	100	143	100
12035	71	75	92	75	92	67	87	67	59	50	85	75
12040	40	17	51	33	41	17	33	8	32	8	44	17
AVERAGE FOR STATIONS	54	39	64	52	64	42	58	43	48	27	63	40

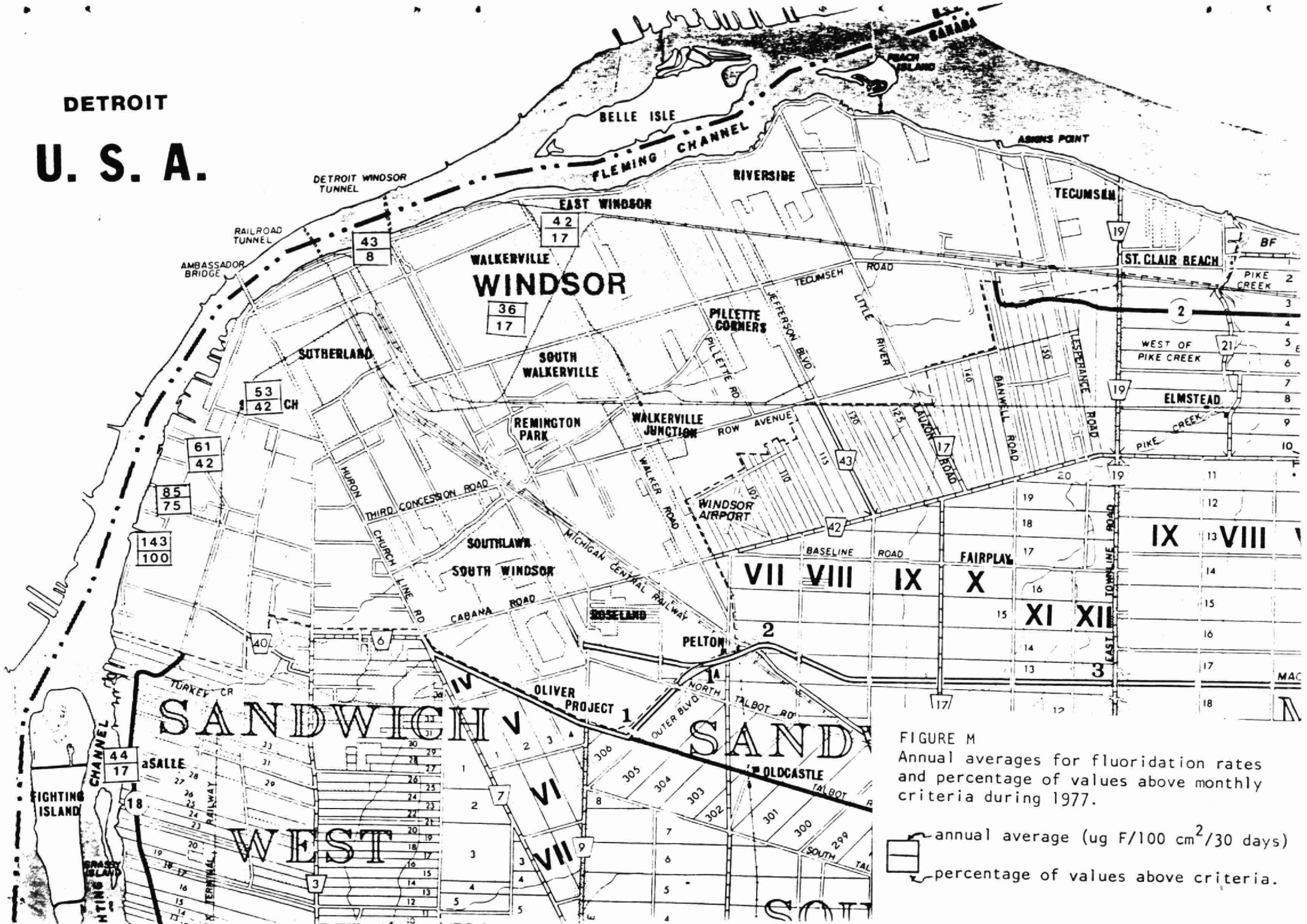


FIGURE M
Annual averages for fluoridation rates and percentage of values above monthly criteria during 1977.

annual average (ug F/100 cm^2/30 days)

percentage of values above criteria.